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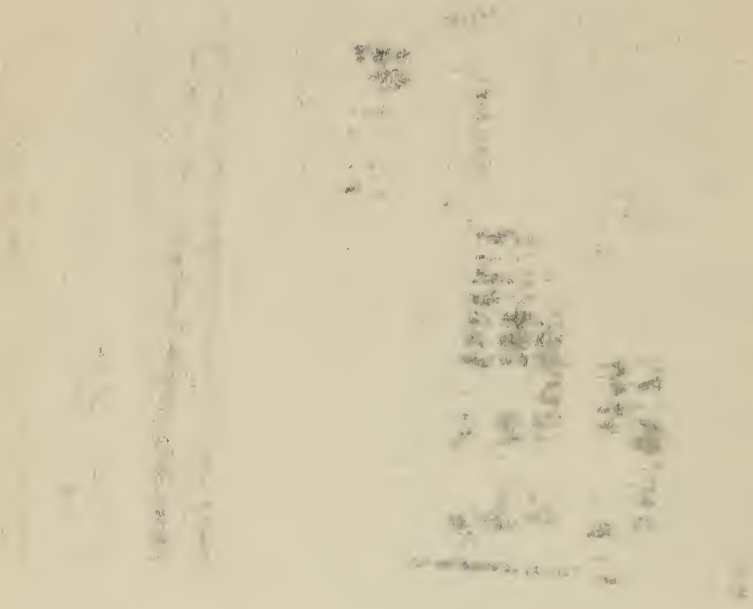

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MEMORANDUM,

WITH

ACCOMPANYING PLANS AND DOCUMENTS

RELATIVE TO

THE PAST AND PRESENT STATE

OF

THE HARBOUR OF TORONTO,

PROVINCE OF ONTARIO.

PREPARED BY DIRECTION OF

THE HON. H. L. LANGEVIN, C.B.

MINISTER OF PUBLIC WORKS

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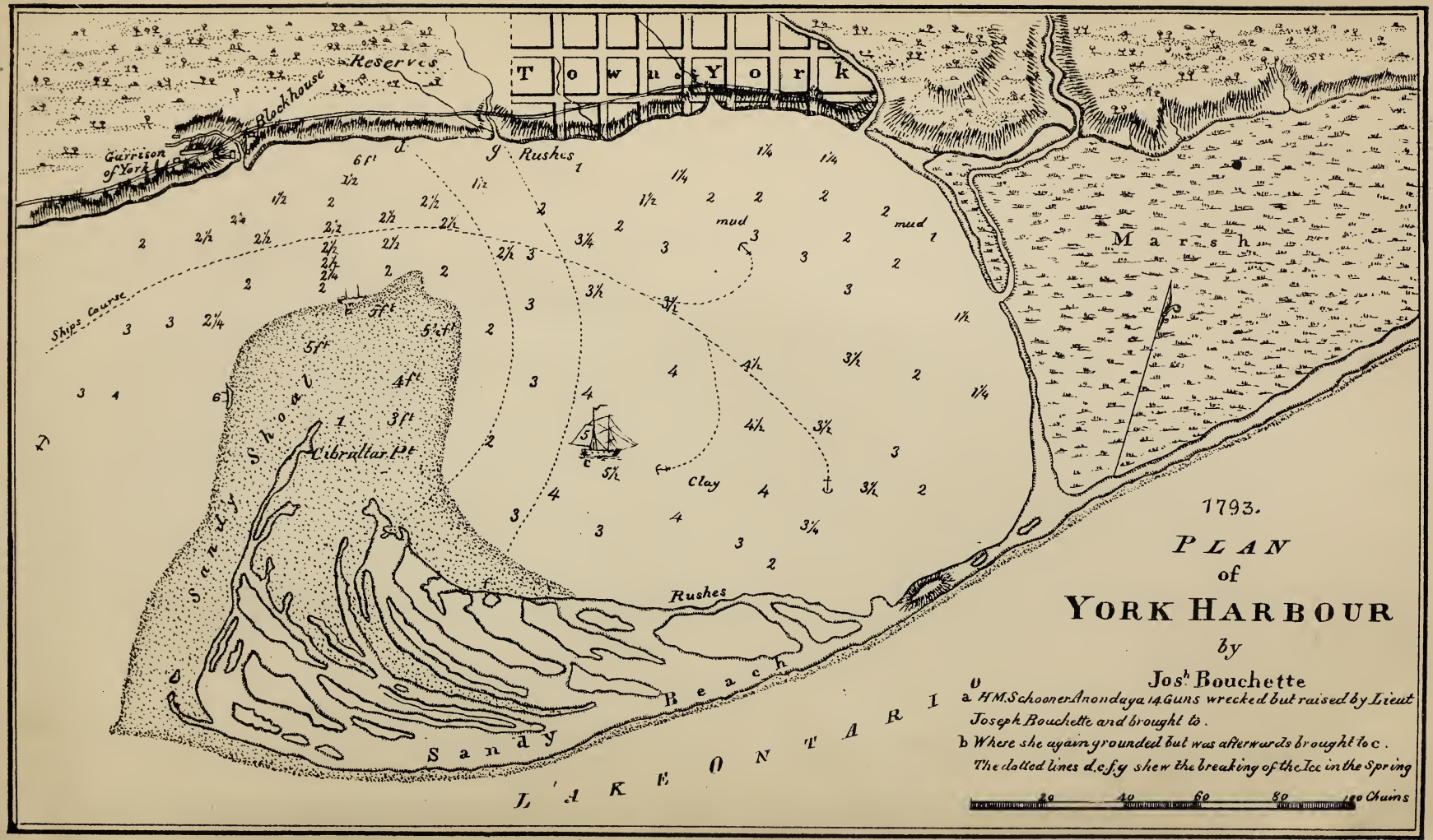
OTTAWA:
PUBLISHED BY THE DEPARTMENT OF PUBLIC WORKS.

1881.



Published by W. Faden Charing Cross Aug^t 12^th 1815.

CONFIDENTIAL.

MEMORANDUM.

TORONTO HARBOUR, ONTARIO.

Toronto, formerly York, is situated on the northern shore of Lake Ontario, in lat. 43° 38′ 10″ N., and long. 79° 23′ 45″ W., 333 miles by rail south-west from Montreal, 161 miles from Kingston, and 39 miles north by east from Hamilton.

The harbour is formed inside of the Island, and has its principal entrance from the westward. An entrance known as the 'Eastern Gap' has existed for some years, but, owing to its shallowness, is not used by steamers or sailing craft of large dimensions. At the north-eastern corner the Don empties; and the eastern side is bounded by marshy lands of many acres in extent, which separate it from Ashbridge's Bay.

In 1788 this harbour was minutely described by J. Collins, Deputy Surveyor General, in a report presented to Lord Dorchester, Governor General, on the Military Posts and Harbours on Lakes Ontario, Erie and Huron. Mr. Collins stated it to be "near two miles in length from the entrance on the west to the isthmus between it and a large morass on the eastward. The breadth of the entrance is about half a mile, but the navigable channel for vessels is only about 500 yards, having from three to three and a half fathoms water. The north or main shore, the whole length of the harbour, is a clay bank from twelve to twenty feet high, and gradually rising behind, apparently good land and fit for settlement. The water is rather shoal near the shore, having but one fathom depth at one hundred yards distance, two fathoms at two hundred yards; and when I sounded here the waters of the lake were very high." ("Toronto of Old," by Dr. Scadding, p. 16.)

The first survey of the harbour was made by Bouchette in 1793, and a copy of his plan is attached hereto.

In his work on the "British Dominions in North America," published in 1832, Mr. Bouchette describes the Harbour of Toronto as follows :—(Vol. 1, p. 88.)

"The Harbour of York is nearly circular, and formed by a very narrow peninsula stretching from the western extremity of the Township of Scarborough in an oblique direction for about six miles, and terminating in a curved point nearly opposite the garrison; thus enclosing a beautiful basin about a mile and a half in diameter, capable of containing a great number of vessels, and at the entrance of which ships may remain with safety during the winter. The formation of the peninsula itself is extraordinary, being a narrow slip of land, in several places not more than sixty yards in breadth, but widening towards its extremity to nearly a mile: it is principally a bank of sand, slightly overgrown with grass; the widest part is very curiously intersected by many large ponds that are the continual resort of large quantities of wild fowl; a few trees scattered upon it greatly increase the singularity of its appearance, it lies so low that the wide expanse of Lake Ontario is seen over it; the termination of the peninsula is called Gibraltar Point, where a blockhouse has been erected. A lighthouse at the western extremity of the beach has rendered the access to the harbour safely practicable by night. The eastern part of the harbour is bounded by an extensive marsh through which the River Don runs before it discharges itself into the basin."

"No place in either province has made so rapid a progress as York. In the year 1793 the spot on which it stands presented only one solitary Indian wigwam; in the ensuing spring it was selected by Governor Simcoe as the seat of Government for Upper Canada."

With the growth of the population and the clearing and cultivation of the surrounding lands, and notably the disappearance of the Scarborough Heights to the eastward, from whence was derived the materials forming the peninsula, changes were soon apparent in the state of the harbour, and the necessity for its preservation early engaged the attention of those who were interested in its maintenance and improvement. They viewed with alarm the changes which had taken place in the dimensions of the peninsula, and the encroachment of the shoal from Gibraltar Point northward, to the great detriment of the entrance, and so early as 1833, as appears by the journals, Upper Canada Legislature, 1833-34, a select Committee reported on certain reports submitted by Captain Richardson and Captain (afterwards Sir) R. H. Bonnycastle, Royal Engineers, on its preservation. (App. p. 1, *et seq.*)

The Commissioners in their report recommended the construction of a work extending from the island along the top of the shoal to the buoy, in a manner to continue the island to the brink of the channel opposite the present pier (Queen's Wharf), contracting the channel to about 700 feet in width; and also to prevent the waters of the Don from entering the harbour. (App. p. 2.)

Captain Richardson's letter is but an amplification of the views of the Commissioners, of which he was one.

The opinions entertained by Captain (afterwards Sir Richard) Bonnycastle to make the harbour a secure and effectual one for large steamers and deep draught vessels were divided by him into three general propositions:—

1st. That of damming up the western estuaries of the Don;

2nd. The opening a passage through the eastern end of the peninsula; and

3rd. The construction of a breakwater from the shore at the western entrance, with works over the whole length of the shoal from Gibraltar Point, to confine the western entrance.

Sir Richard proceeded to debate the first proposition and arrived at the conclusion that it did not signify whether the breaches which the Don had made into the harbour be closed or not, and believed that the river is useful in a very slight degree.

With respect to the second proposition he plainly stated that if an opening be made through the beach the harbour would be entirely destroyed, and if it be done, extensive works must be run out into the lake, etc., to arrest and retain the shingle which is (was) brought by the wasting away of the Scarborough Heights from the eastward, and so to prevent a silting up of the channel so formed; but he feared that a navigable channel could not be kept clear, and that vessels would experience much difficulty during gales from the east around by the south to the west, in entering such a channel, and he summed up with the statement that there could not be any harm in making a small canal shut in by flood gates and protected by piers, and that under these restrictions no obstacle would be thrown in the way, and that it would be very useful for the purposes of trade.

The third proposition is discussed at length, and the conclusion arrived at was that the western entrance should be protected and maintained.

It appears that no action was in any way taken on this report, and though the matter engaged attention, little or no regard was paid to the state of the harbour, though a Mr. Roy, C.E., drew attention to its state in an article published in the *Monthly Review* in June, 1841. Search and inquiry have failed to obtain a copy of this paper.

Under date 4th May, 1847, Mr. C. S. Gzowski, then an engineer in the service of the Department of Public Works, reported that the entrance had narrowed to 250 feet in width, the bar having increased 280 feet in a northerly direction in *seven* years. (App. p. 17.)

In 1850, Mr. Sandford Fleming, C.E., read a carefully prepared paper before the Canadian Institute, in which he entered fully and minutely into the theory of the formation of the peninsula, described the changes which it was constantly undergoing, and its great increase in area since Bouchette's survey in 1793, and he debated the propositions which had been made and concluded:

1. That the foundation of the peninsula in its early stages may be attributed to the *debris* of the country traversed by the Don, in conjunction with a drift from an ancient promontory at Scarborough.

2. That the more recent portions were formed by materials from the Scarborough Heights.

3. That the formation is due to the travelling of the sand and gravel, under certain action of the waves.

4. That the harbour was being impaired and its only entrance threatened with early destruction by the same cause.

5. That its preservation may be permanently affected by the construction of certain specified works, at well selected points.

6. That the waters of the Don should be permanently excluded.

7. That the opening of an eastern passage would be a great accommodation to shipping; might improve the purity of the water in the harbour; and, if the necessary works to preserve it were properly executed, would have a beneficial effect.

Early in 1852, Mr. Walter Shanly, C.E., at the request of the Harbour Master, submitted for the information of the Harbour Commissioners a report on the state of the channel and the improvements required. (App. p. 18.) In it he stated that from the ob-

observations and soundings recorded during twenty years by the Harbour Master it was ascertained that the bar had advanced northwardly across the entrance at the rate of 19 feet yearly, and that the available width of the channel was scarcely 200 feet.

Mr. Shanly's theory of the formation of the peninsula is that the materials forming it were brought from the westward, and that the Don assisted as well, and he states that were the operations of Nature left unmolested, future generations might walk dry shod across to the outer lighthouse.

The remedy he proposed was dredging and the construction of crib-work on the southern side of the channel to define and maintain its width ; and to divert the Don into Ashbridge's Bay.

Mr. Kivas Tully, C.E., in a letter dated 10th February, 1853, discussed fully the need of permanently improving the harbour, alluded to the opening of a passage through the peninsula, now known as the Eastern Gap, and suggested its improvement from an economical point of view—

1. On account of the saving of time to vessels arriving from or departing to the eastward, and

2. The tendency of the current created to maintain an open harbour later in the fall and earlier in the spring.

In the appendix, page 22, will be found an able review from the journal of the Canadian Institute, vol. 1, p. 162, of the letters and reports by Messrs. Bonnycastle, Shanly, Fleming and Tully.

In 1850 the harbour was placed in commission, Captain Richardson being Harbour Master. This gentleman in January, 1854 submitted to the Commissioners a report on the state and requirements of the harbour, and alluded to the many changes which had taken place over a period of 50 years, and of the necessity which then existed for steps being taken to ensure the preservation of the western entrance in a navigable state, and to a depth of 14 feet and a width of 400 to 500 feet. He alluded to a breach through the peninsula to the eastward, near Privat's Hotel, which was then only 140 feet in width. Reference is made to an old chart of about 1800, on which the western entrance was shown to be about 1,455 feet in width from 12 feet inshore to 12 feet on the bar, and that the soundings in the channel were 3 and 3½ fathoms. (App. p. 27.)

This report bore fruit, for the Harbour Commissioners in March, 1854, offered premiums for the three best reports on the means to be adopted for the preservation and improvement of the harbour, the points to be discussed being :—

1. The effects, present or future, to be produced by the breach (Eastern Gap) through the peninsula on the harbour.

2. If prejudicial, the means to be taken to strengthen the coast against further encroachment.

3. If beneficial, the proper mode of making it useful, and the cost of doing so.

4. The advisabilty of opening a passage between the harbour and Ashbridge's Bay, or an opening from the last into the lake, with an estimate of cost.

These premiums were obtained by Messrs. Hind, Fleming and Tully, and an extra premium was awarded to Captain Richardson for a report submitted by him.

The reports were published at the expense of the Harbour Commissioners, and will be found in the Appendix p, 30, *et seq.* They furnish a vast amount of information respecting the harbour, and discuss fully the questions submitted by the Commissioners. No attempt is made by the writer to condense the views and opinions expressed in these different reports, because to do so would necessitate the use of extended quotations, which is not within the province of this memorandum.

No action was taken on any of the suggestions made by the writers of these reports as regards the construction of works; but it is gathered from subsequent reports by the Harbour Master—Captain Richardson—that dredging plant was obtained and used to keep the western entrance from closing up.

In 1856 it appears that the available width of the western entrance for deep draught vessels was only 260 or 270 feet, although dredging had been carried on for some time. At that date 400 feet was considered to be the least width, and 12 feet the least depth, which should be obtained. (App. p. 94.)

In his report for 1857, the Harbour Master states that many changes had been observed in the shape of the island; and that the point bounding Blockhouse Bay on the western side had greatly increased northwardly. He alluded to damage done to the pen-

insula, that the embankment for its preservation was never finished, and did not advise its repair. (App. p. 95.)

From the report of 1858, it is gathered that a breach had been effected through the peninsula, and that the influx of water into the harbour from the eastward was deemed to be of great benefit. (App. p. 96.)

At the end of 1859 the neck of land at the peninsula had disappeared, and a navigable channel with from 7 to 8 feet of water had taken its place, and new formations of sand on either side appeared. (App. p. 98.)

In the report for 1860 it is stated that the western entrance having been dredged to 400 feet in width, and an average depth of 12 feet, both had been maintained ; and that the island shoal had extended westwardly and threatened to encroach on the channel. The depth in the eastern channel was 6 feet. (App. p. 99.)

Capt. Richardson, in his report for 1861, refers to the opening at the eastern end of the harbour as having been the means of purifying the water in the harbour, and of contributing to the health of the city.

The island shoal had extended further to the westward, and beyond the influence of the current deflected and guided by the Queen's Wharf, and the channel had been maintained at its width of 400 feet. (App. p. 100.)

Mr. S. Keefer, then Deputy Commissioner of Public Works, in reporting on a petition of the Council of the Corporation of the City of Toronto, that a survey of the harbour be made " with a view to ascertaining the cause of the dilapidations which have already taken place, and of devising some means of arresting their progress," refers to the reports of the gentlemen who had in previous years examined the harbour, and stated the results of his own examination, and advised that a careful survey should be made under the direction of an able hydraulic engineer, as " the subject requires to be treated both theoretically and practically, with a view to the satisfactory delineation of the causes which have operated in the formation, but are now apparently directed to the destruction of the harbour; as well as devising some plan for directing them beneficially in future for its preservation and protection. The problem not being easy of solution should therefore be committed to the ablest hands."* (App. p. 101.)

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* The date of this report should be 1862, instead of 1872, as printed.

No action was taken on this recommendation.

The Harbour Master, in his report for the year 1862, stated that a bar of sand had grown up inside the eastern entrance over which the water was shoaler than in the entrance itself. The "gap" or entrance had increased to half a mile in width, and the line of beach had so far receded that a boiler of a wrecked steamer which formerly was high and dry, was then 100 yards out in the lake and in deep water.

At the western entrance the island shoal had extended to 300 feet west of the then west end of the Queen's Wharf, and had advanced northwardly 40 feet. (App. p. 103.)

During 1863, following the suggestions of the Harbour Master, the Queen's Wharf was extended westwardly 200 feet, and, up to the end of 1864, a channel 400 feet in width, with a depth of 13 feet, had been secured.

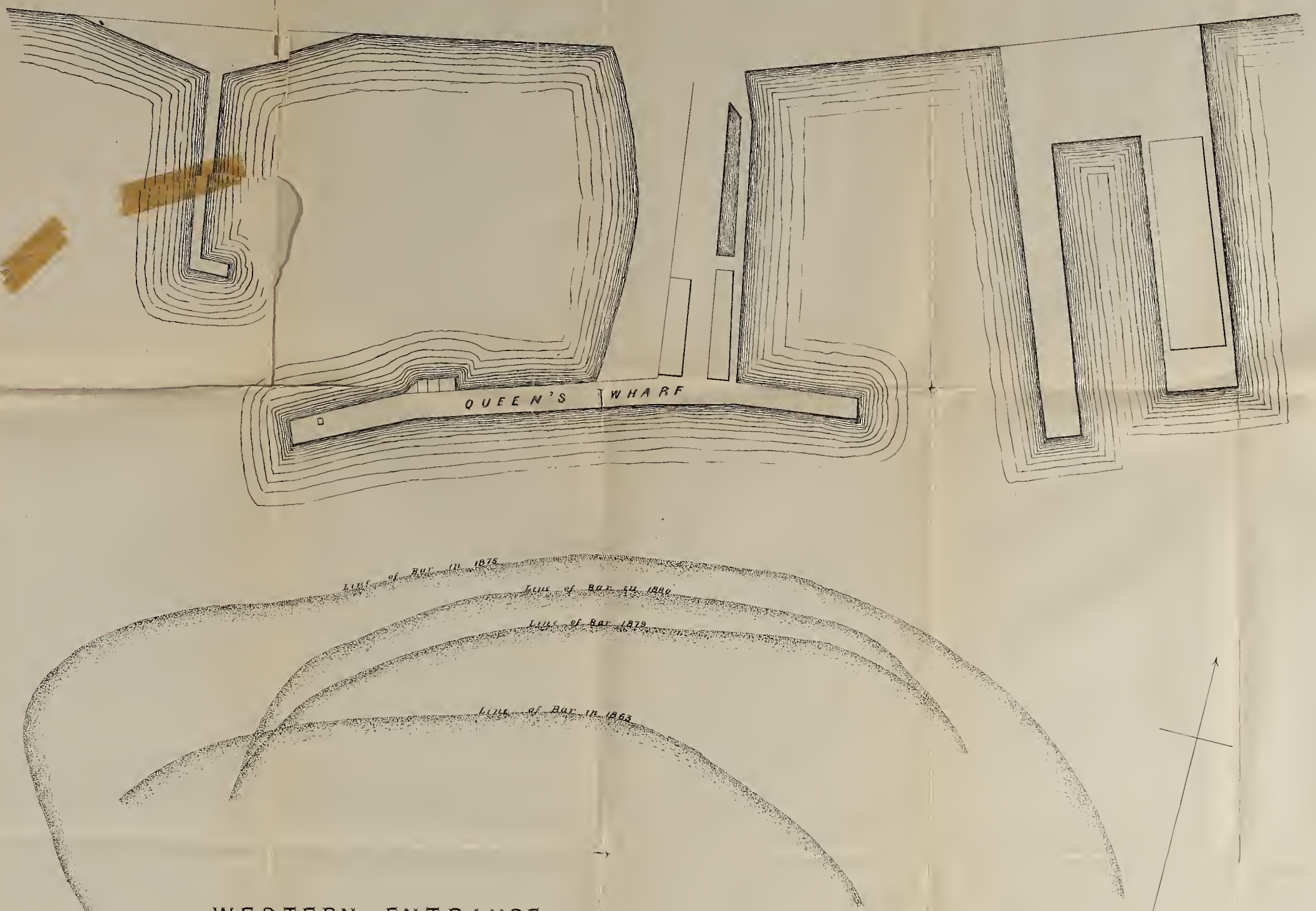
The bar inside of the Eastern Gap had been thrown farther into the harbour, and had only 6 feet of water on it, thus limiting the passage to vessels of light draught. (App. p. 105.)

In his report for 1865, Captain Richardson stated that the Highlands of Scarborough, the source from which the materials composing the peninsula and island were derived, no longer existed, and therefore a wasting away of the latter was going on.

The western entrance maintained its width of 400 feet, and a depth varying from $11\frac{1}{2}$ to $14\frac{1}{2}$ feet, according to the height of the water in the lake. The island shoal still progressed westwardly, and during 34 years had increased in width 700 feet, or at the rate of 22 feet annually. (App. p. 107.)

Mr. Kivas Tully, Engineer to the Harbour Board, reported that during 1866 the western entrance remained at 400 feet in width, which was due to the extension of the Queen's Wharf westwardly (App. p. 108); and, in his report for 1867, again referred to the westerly increase of the island shoal, and stated that "the formation west of Lighthouse Point had increased during the last few years, and an additional tongue or arm" (now Hanlan's Point, see plan showing changes in the harbour during 1874, 1875 and 1879) "had formed, which trends in a northerly direction about 300 yards west of the island, making another bay; this formation no doubt will continue to increase." (App. p. 109.)

This tongue, or arm, now known as Hanlan's Point, has increased up to 1880 until it now extends northwardly beyond Gibraltar Point, and the shoal from it has been pushed



WESTERN ENTRANCE
OF
TORONTO HARBOR
SHEWING
CHANGES OBSERVED
IN THE
YEARS 1863, 1875, 1879, 1880

SCALE
$\frac{1}{1200}$

GEO. E. DESBARATS PHOTO-LITH MONTREAL

forward yearly until in 1875 it had narrowed the western entrance to a width of 230 feet —see plan herewith.

In 1875 a report (App. p. 109 *et seq.*) was submitted to the Secretary of the Department of Public Works, by Mr. Wm. Kingsford, engineer in charge, who entered fully into the state and requirements of the harbour, and advised that the Parliamentary grant of $20,000 should be expended in dredging, as "the present approach to Toronto by deep water necessitates an abrupt turn to enter the 'Queen's Wharf Channel.' In the improvement contemplated, easy entrance and egress should be secured;" and that "the increased navigation of the canal system of the Dominion points out that the entrance should ultimately be 16 feet deep."

Between 1st July, 1874, and 30th June, 1880, the sum of $49,120.90 had been expended, principally in increasing the width and depth of the 'Queen's Wharf Channel.' Shortly after dredging was commenced it was found that, to obtain a depth of 16 feet at low water, it would be necessary to blast in solid ledge, and to a certain extent this was done. No attempt was made to straighten the abrupt turn, or to render the channel any easier for entrance or exit, the object being the opening of a channel 300 feet in width with 16 feet of water on the old course.

On the plan of the western entrance herewith will be seen the encroachment of the point of the shoal northwardly, and the width of the navigable channel in 1863, 1875, 1879 and 1880.

A plan of the harbour is attached, showing its state in 1841 (?), and it may be compared with that showing the changes observed in the eastern and western entrances in the years 1874, 1875 and 1879.

At the Session of Parliament of 1880, the sum of $12,500 was appropriated for expenditure in this harbour, part of that amount to be expended in dredging the western entrance, which in the spring of 1880 had been narrowed to 280 feet by the growth of the Island shoal northward.

As the present entrance has been pronounced to be abrupt, and it is known that to obtain a depth of 16 feet at low water would necessitate the removal of a large quantity of solid rock at a very great expense, it was judged that—as in former years the entrance was some 500 yards in width with deep water, a comparatively straight cut might be

made through the point of the shoal, and a depth of 16 feet obtained without touching the rock. A line of easy entrance from 18 feet outside to the same depth inside was laid out, and a series of borings made showed that a depth of 17 feet below zero of the gauge on the Queen's Wharf could be had without the removal of any rock. This line is about 700 feet to the southward of the Queen's Wharf, and dredging operations have been commenced in the removal of the point of the shoal northward of this line. The material to be removed is fine sand.

It has been deemed desirable to include in the Appendix a letter by Mr. J. G. Worts, the Chairman of the Harbour Board (p. 115), and also the petitions to His Excellency the Governor General from the Mayor and Corporation of the City of Toronto, and the Harbour Commissioners, praying that steps be taken by the Federal Government to protect the harbour and preserve it for the future. (p. 117, *et seq.*)

As, throughout the whole of the reports published in the Appendix, constant reference is made to the height of water in Lake Ontario, and the effects its variation periodically has had upon the changes which have taken place in the peninsula, now island, bounding the harbour on the south, and in the harbour itself, there has been attached an article from the "Canadian Journal," vol. 2, entitled "Variations in the Level of the Lakes," which may not be out of place in connection with the object of this memorandum. Through the courtesy of Mr. Kivas Tully, C.E., who as Harbour Engineer has an intimate acquaintance with the harbonr, and the many changes which have taken place during very many years, permission has been given to attach a copy of his paper on "The Fluctuations of Lake Ontario from the year 1854 to 1878," and of the chart prepared to accompany it. (App. p. 132.)

The writer believes that he has touched upon the salient points of the reports and documents which have been gathered and printed herewith. That it has been shown that in early days, nearly 100 years ago, the width of the western entrance was nearly 500 yards; that on each successive examination this width was found to be gradually lessening; that through natural causes an opening was made through the peninsula at the eastern end of the harbour, and that a wide and comparatively shallow entrance now exists; and that for nearly half a century it has been the desire of those interested in the welfare of the harbour that steps should be taken to ensure its preservation for the future: that, though many reports have been made and suggestions and estimates of cost submitted, none have been adopted nor acted upon, even in part; and the same

forces of Nature which have acted through past years are still acting unchecked to the detriment and possible destruction of the finest harbour on Lake Ontario.

It may not be amiss here to state that the waters of the Don and the sewage from the city still empty into the harbour.

The questions have therefore arisen what course is to be pursued, what is to be done to preserve this harbour; and further is it necessary or desirable so to improve the eastern entrance as to maintain always a navigable depth of 16 feet; and to construct such works as may be required to restrain the encroachment of the Island shoal, and preserve the western entrance at such a width and depth as will give easy access and exit? On the proper solution of these questions depends the preservation of Toronto Harbour.

The writer has to acknowledge the assistance he has received from Mr. M. Baldwin, the Harbour Master, and Mr. Helliwell, the Deputy Harbour Master, in obtaining many of the reports published herewith; and his thanks are due to Mr. K. Tully, C.E., for his reports and paper on the lake levels.

Respectfully submitted,

HENRY F. PERLEY,
Chief Engineer.

Chief Engineer's Office,
Department of Public Works,
April 11th, 1881.

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(Journals, Upper Canada, 1833-34, *p.* 175.*)*

REPORT

Of Select Committee on Communication from His Excellency the Lieutenant-Governor, on the improvement of the Harbour at York.

TO THE HONOURABLE THE COMMONS HOUSE OF ASSEMBLY.

THE COMMITTEE *appointed to take into consideration the communication of His Excellency the Lieutenant-Governor on the subject of the Harbour of* YORK,

MOST RESPECTFULLY REPORT—

That, having carefully examined the Report of the Commissioners appointed by the Acts of last session for erecting a pier at the mouth of the harbour, the paper of Captain Richardson and that of Captain Bonnycastle, have agreed to recommend the granting of a sum of money amounting to £500 to complete the pier now in progress, upon the same terms as were provided in the Bill of last session.

That, as the Town of York will, in all probability, be incorporated by Act of Parliament this session, the Committee do not feel justified in recommending at present any further grant; leaving it to the local authorities under the municipal government to make such improvements towards effecting the desired object as to them may appear necessary.

All of which is respectfully submitted.

W. B. JARVIS,
Chairman.

COMMITTEE ROOM, House of Assembly,
13th day of February, 1834.

REPORT

Of the Commissioners appointed to superintend the improvement of the Harbour of York.

To His Excellency Sir John Colborne, K.C.B., Lieutenant-Governor of the Province of Upper Canada, etc., etc.

The Commissioners for the improvement and preservation of York Harbour beg leave to report to His Excellency the Lieutenant-Governor, and for the information of the Legislature, that the pier now in progress of construction at the entrance of the harbour, is extended out into eight feet of water ; but, as the waters are unusually low, (they having fallen upwards of two feet since the commencement of the work), it is presumed that from nine to ten feet of water may generally be reckoned upon at the pier head.

In consequence of the outer crib being carried away from its moorings the night of the day it was laid down, in an almost unprecedented storm, an extraordinary expense was incurred to recover it, and it became necessary to carry it out about 75 feet farther than originally intended, to avoid part of its wreck there remaining, and to construct another one for the express purpose of covering the wreck.

The pier is now raised its whole length, upon an average, two feet above the water, and partially filled with stone. Of the £2,000 placed by the Legislature at the disposal of the Commissioners for the above purpose, £1,600 has been already expended, leaving a balance in their hands of £400.

To raise the pier, as required, six feet above water, secure it against all casualties, finish it creditably, erect a small pier light, and maintain the same a short period, until a fund be provided for that purpose, the Commissioners are of opinion that five hundred pounds, over and above the balance in hand, will be required.

The Commissioners also take this opportunity of recommending, for the further improvement of the channel and preservation of the Harbour of York, that a work be extended from the Island along the top of the shoal to the buoy, in a manner to continue the Island to the brink of the channel opposite to the present pier, contracting the channel to about seven hundred feet in width, and confining to this outlet *alone* all the influx and efflux of water resulting from the ever varying level of the lake by the action of the wind, and the reciprocating action of the water in the bay, whereby a constant oscillation in the channel is kept up.

But the Commissioners think it necessary previous to ensure that the waters of the bay make no passage by the mouths of the Don, and through the marsh to the outlet at Ashbridge's bay, as it is surmised by them that, when the channel is more contracted, the tendency of the waters of the bay to force a passage by the mouths of the Don will be greatly increased.

Therefore, the Commissioners, looking upon the River Don but as a vehicle for the transport of alluvium into the bed of the harbour, without its waters being to the port of any significant value, suggest, that the mouths of the Don that open into York Bay may

be dammed across, and the course of the Don turned east. Thus to ensure against any breach of the waters of the Bay in that direction, and at the same time arrest the progress of ruin to the port, now so fatally in operation through the destructive agency of the Don. To complete these works a further sum of £1,500 will be required.

The Commissioners wish to consider their duties at an end, when the pier now erecting under their control shall be finished; but in their anxiety to draw the attention of the Legislature to the perishable state of York Harbour, they respectfully suggest the expediency of appointing a permanent and scientific commission to prosecute works in their opinion so urgently called for to secure to the country the best yet most perishable harbour on Lake Ontario.

HUGH RICHARDSON,
W. CHISHOLM,
J. G. CHEWETT.

York, 4th January, 1834.

TO THE INHABITANTS OF THE TOWN OF YORK, AND OF THE PROVINCE OF UPPER CANADA.

Gentlemen,—

If my tree has taken root, I shall never cease to acknowledge that I owe it to your cherished reception.

If opinions, founded upon observations due to the nature of my calling, can in any way be beneficial to your interests, I feel I am only performing a grateful duty in thus presenting them.

I am, gentlemen,
Your very obedient and very humble servant,

HUGH RICHARDSON.

YORK HARBOUR.

Anxious to draw public attention to the state of York Harbour, and impressed with the idea of the correctness of my views, I lay them in candour before the public, as interesting to the commerce of Upper Canada, and, if correct, as vital to the prosperity of the Town of York.

To those unacquainted with, or whose vocations deprive them of opportunities of observing the silent and sub-aqueous operations of nature in the port, I need scarcely

apologize for laying before them the result of long observations. To the scientific, I submit my opinions with deference to their better judgment.

I may first, then, remind the country, that we had but three natural ports on the British side of Lake Ontario—those of Kingston, York and Niagara, until the once Burlington Bay, by the hand of art became a fourth.

Of the four, that of York, the seat of the capital, possessing more of the natural properties of a good harbour than any of the rest, (having, besides its splendid basin, an excellent outer roadstead), is the only one approaching to the verge of ruin.

Kingston Harbour may be called an arm of the lake. Its outlet is too great for any serious inconvenience to be felt for years from the deposit of the great Cataraquoi River.

The Niagara River (definitely speaking) is imperishable; and a private company has enterprisingly seized upon and excavated the basin of the port, thereby giving the port a value before unknown, disarming the river of its winter terrors, and turning the current of the river to the profitable account of keeping an open port, when most others are closed.

Burlington Harbour approaches nearest in aspect to that of York. It is of about the same dimensions—has the Dundas Creek falling into it as that of York has the Don; but then it has fifteen fathoms of water in a large area, whilst the Bay of York has only 29 feet, confined to a very small one, thereby rendering inches of more value to the Port of York than feet to Burlington.

It may be necessary, for the information of those unacquainted with the Harbour of York, first to describe it;—I shall then transfer so much of a paper that I had the honour to read elsewhere as accounts for its formation, and for the causes and progress of its decay, and as suggests means for its preservation.

York Harbour is an elliptical basin of an area of eight or nine square miles, formed by a long sandy peninsula stretching from the land east of Ashbridge's Bay, in a S.S.W. direction to a point abreast of the present Fort, from which it is about two miles distant, and upon it is a lighthouse; thence it stretches towards the shore, N.N.W., about three quarters of a mile, then dips under water, continuing in the same direction, carrying on it from two to three feet water, until, within about 1,500 feet of the shore; it then breaks off, dropping suddenly down from the spot where the buoy is laid, to thirteen feet, soon deepening to fourteen and a half, the deepest bed of the channel, which is mud. Here ends the island sand. The channel then gradually shoals towards the shore; at 13 feet you strike rock, and 700 feet from the shore you have 9 feet water, leaving a channel from that depth out to the buoy about 815 feet wide.

I shall now state, as briefly as possible, the theory of the formation of the port, and commence by assuming as a fact, that Lake Ontario came to its present level, not by any gradual descent, but as suddenly as the torrent sweep of the waters would allow, disengaged as they have been by the disruption of a barrier or some rocky dam that held them suspended for ages at a much higher level. I say at a much higher level, because there are various phenomena of the long and continued action of the wave in many parts of the adjacent shore, particularly the well known causeway of the ridge-road betwixt Lewiston and Rochester. It is not my purpose to explain these phenomena, but, assuming them as proof of what I now assert, state that the lake has suddenly and violently been reduced to its present level, and that the effect produced by the action of the waters at that awful epoch was nothing more than what we daily see as the miniature result of any common freshet.

If that a mill-dam break away that has so long upheld a pond as to have raised its bed by alluvial deposit above the level of the former bed of its creek, and this dam break suddenly away, what is the result? No sooner do the rushing waters descend below the level of the artificially raised bed, than they cut away such portion of the made soil as is immediately in their course, and leave the remainder in cloven and precipitate banks above.

Such then, I presume, has been upon a mighty scale the process upon Lake Ontario. The waters have retired violently, and, in many parts, below the level of their ancient bed; and where this has happened in soil capable of removal, such as the flats below Scarborough Heights, the operation of the mill-pond is strictly exemplified. I adduce the Scarborough flats as immediately connected with my subject.

I will now suppose the great agitation of the waters subsided, and that the lake stood at its present level, without a shoal formed by the action of the wind and wave,—without a shoal formed by the present tributary streams, which are all coeval to that awful era.

At this period commenced upon its virgin shores, the works of dilapidation and deposit, dilapidation by the action of the wave, and its consequent deposit; and deposit from the tributary streams.

There is indication enough to presume, that the high and bluff promontory of Scarborough extended at that era, much farther out into the lake than it does at present; that since, torn periodically by the eastern gale, and its wreck swept along the shore by the stormy wave, struck past the indenture of the land about Ashbridge's Bay and York, and sprinkled its first deposit in the direction of the wind, laying the foundation of the peninsula, as simply as a pail of sandy water, thrown into a clear pool, would depose the sand in the direction in which it was thrown. And thus has fallen from the charged wave of the storm, deposit on deposit, until, from the bosom of the lake, uprose the peninsula—the work of ages of repetitions, and the monstrous index of the ravages of countless easterly storms upon the highlands of Scarborough.

The same cause is still in operation, producing similar results—the progressive increase and march of the peninsula west, but with this variation, that the farther the formation is removed from the source of its supply, the more it is inclined to spread, the water only bearing along so great a distance the smaller and easiest suspended particles. Hence its great breadth at the west end, and narrow neck at the east. A continuation of the peninsula is the transverse shoal that stretches across the entrance of the bay to within a few hundred feet of the shore, where it is suddenly broken off by the passage of the waters that keep the channel open.

This latter part of the formation is due to a phenomenon peculiar to the easterly storm upon the lake,—the almost invariable and sudden shifting of the wind to the opposite direction, combined with the outset of the waters of the bay, already raised by the easterly gale above their natural level, consequently falling with the shift of wind.

It must be generally understood, that the north-east wind raises the water at the west end of the lake more or less according to its violence, and *vice versa* wth the south-west wind.

Thus, at the close of most of the easterly storms, whilst the lake is yet in commotion, and the seas ranging along the peninsula charged with alluvial matter; the wind shifts to the south and south-west, the charged waters are driven in upon the Bay of York, whilst the waters of the bay are making outwards to regain the level of the lake, now lowering at the west, with the change of wind; and as the line of conflict betwixt the wave of the wind setting in, and the raised waters of the bay setting out, is at the verge of the bay, here is a consequent deposit. In other words, the waters of the lake charged with sand by the easterly storm, and driven back upon the bay by the shifting wind, are opposed at the entrance by the outsetting waters, and there forced to depose their burthen.

This shoal, or bar, would stretch right across the entrance of the bay, and reduce the channel to a few feet in width and a few inches in depth, sufficient to dribble forth the puny waters of the Don, but for the continued varying levels of the lake (affected more or less by every wind) and the reciprocating action of the waters of the bay producing in the channel a constant oscillation, or flux and reflux, by which a good and deep channel is kept open, and in which I find as much water now as in the time of the oldest surveys, say fourteen and a half feet.

Why the waters make themselves a passage along shore, and consequently keep there the channel of the port, to me is obvious. It is, that being met by the brisk westerly or easterly gale in their attempted passage over the shoal (ever to windward) to assume the level of the lake, setting out with the west wind, setting in with the east, they are dammed back by the ripple of the wave, or broken water, and the great body makes its way in under current along the shore, where it finds least obstruction from the opposing wind. Even the partial wind blowing in or out of the bay, carrying the surface water to leeward; sinking or over filling the bay, that water is constantly returning in under current by the channel of the harbour to restore its equilibrium. Blow along

a narrow channel connecting two vessels filled with water, you will keep up a constant stream on the surface into one, and yet you will scarcely alter the level of either, as the water will return in under current almost in the same ratio as it is driven by the surface from one vessel into the other.

The indication of this current, or oscillation of the waters in the channel, is the sudden breaking off, rounding, and steep declivity of the shoal or spit extending from the island to the buoy, where its progress is arrested by the passage of the waters, and where it falls from 4 to 13 feet immediately, soon deepening to 14½, and here totally ends the island sand; and mud, the alluvial deposit of the harbour, begins.

Thus far the formations of the port; but nature, in parcelling out this beautiful sheet of water from the lake, enclosed within its bosom the seed of its decay.

The Don, like its relatives in consequence, the Humber, the Highland Creek, the Rouge, the Credit; whilst it dribbled its puny waters into the great lake, was, in importance, as the fly upon the horn of the bull:—but once embayed by the formation of the peninsula (like many a worthless fellow who owes his consequence to fortuituous circumstances) from total insignifiance it became the grand agent of destruction to one of the finest harbours on the lake.

The peninsula (from a vast shoal) has risen out of the lake at the western extremity, from a depth of 25 to 30 fathoms, and the bay has carried within it at least 15 fathoms at its deepest part.

But, from the moment the peninsula raised its protecting head above the waters, and screened the Don from the surges of the lake, the Don, like a monster of ingratitude, has displayed such destructive industry as to displace by its alluvial disgorgings by far the greater part of the body of water originally enclosed by the peninsula. The whole of the marsh to the east, once deep and clear water, is the work of the Don, and in the Bay of York, where now its destructive mouths are turned, vegetation shows itself in almost every direction, prognosticating the approaching conversion of this beautiful sheet of water into another marshy delta of the Don.

However the Don has been assisted in the work of filling up in some measure by the peninsula itself. For, whilst the easterly storm furnishes the material, the south and south-west winds, when dry and stormy, send the sand into the bay in large drifts; thus the branch-like and encroaching ridges at the west end of the peninsula.

I trust now to convince the public that the Harbour of York owes nothing to the Don but its decay! It owes nothing to the Don for the navigableness of its channel. The waters of the Don can be of no more value to the channel of the port, than they are to the channel of itself. That is, were the channel of the Harbour of York solely dependent on the waters of the Don, it would be just as navigable as is the channel of the Don, which is not navigable at all.

Imagine the Bay of York completely dammed across the entrance, so as to exclude the waters of the lake at their highest level, with only a waste weir sufficient to carry off the waters of the Don. The sum in feet and inches of a section of this weir would be the sum total of the value of the Don to the navigation of the port. In the summer months it would scarcely float a boat.

The harbour owes the preservation of its channel entirely to the fluctuating levels of the waters of the lake, producing in it a series of oscillations or of alternate currents, forbidding all deposit in the immediate theatre of their action. And as the strong east and west winds have a direct opposite tendency upon the levels of each water; that is, the east wind to raise the lake while it lowers the bay, and the west wind to lower the lake whilst it superficially is filling the bay, it follows that the greatest variations of levels are produced by these winds; and the process of restoring the equilibrium must be effected, and is effected in under current in the channel, whi'st the surface water apparently is carried in an opposite direction.

The strongest proof that the harbour owes nothing to the Don, or to the contributions of all of the streams of the bay together for the navigableness of its channel, is, that in the months of July and August, when the minor streams are to all significance dry, and the Don scarcely affords water enough to keep open even its own channel, that of the port is better and deeper than at any other season of the year.

But, if an actual example of the theory I have laid down be necessary to support my argument, I adduce, as immediately to the point, the harbour of Burlington Bay. It contains about the same area as that of York; it has the Dundas Creek falling into it of equal consequence with the Don. Before the present cut was made that converted the bay into a navigable port, the superfluous waters of the creek dribbled forth at a natural outlet in the beach, varying from six inches to two feet in depth, according to the supply, with a descent of channel sufficient to keep out the waters of the lake. No sooner was the present cut made and dredged down to eight and nine feet, admitting the free passage of the waters of the lake, than it deepened of itself to thirteen and fourteen feet, and the current flowed as often in as out; proving thereby that the channel was entirely due to the fluctuating levels of the two waters.

Now if my positions be correct, that we owe the open channel of our harbour entirely to the varying levels of the lake, and the decay of our harbour chiefly to the Don; what are the means that here suggest themselves of improvement and preservation?

The improvement must be to contract the channel: the grand work of preservation to shut out the Don.

By contracting the channel, no water will be allowed to escape over the shoal, even in calms; and the motion of bodies of water in passing in and out of the channel will be accelerated, and their action felt at greater depths.

In speaking of calms, I have stood upon the lake shore in a perfect calm, and seen the water, by a certain mark, gradually rise and fall seven inches; each returning flux being at the period of a quarter of an hour. This undulation of the lake, I attributed to a partial and violent wind or squall at the east end of the lake, disturbing the equilibrium of the whole.

The process of contracting the channel will not be attended with any difficulty, nor with any expense commensurate to the value of the benefit to be derived therefrom. The first part of the plan is already provided for by the liberal provincial legislative grant of £2,000 to construct a close pier from the shore, to be carried out 700 feet into 9 feet water, this will come to within 820 feet of the buoy on the island spit, which forms the narrows of the channel, and will contract the channel to that width. Now from the buoy to the island, a spit or shoal carries upon it from 2½ to 3 feet water, and over which, to the prejudice of the channel, escapes a vast deal of water, which if confined to it, would be of infinite service.

To obviate this evil, I should propose to raise the crown of the spit above water; that is, to extend a dyke or dam on the top of it from the point of the island to the buoy; and as upon an average there is not above 3 feet water, and the dyke need not be raised above 2, this cannot be attended with a heavy expense. Indeed a very small obstruction would create a bank outside to the westward, and have this advantage, that it would arrest the passage of the island sand over the shoal, which now extends its breadth inwards as well as outwards. With its military point of view I have no concern; but I can only say, that whilst steamers can command 3 feet water out of the point-blank range of a fort, in the event of war, they will prefer accommodating their construction to this convenience in preference to the deeper channel and better mark.

By shutting out the Don you will exclude the grand source of alluvial deposit, which, in one easterly storm accompanied by rain, brings down and spreads over the bed of the harbour more soil than would employ an active dredging machine a month to remove. Even the cultivation of the country increases the destructive powers of the Don, for the plough of the husbandman annually loosening the soil, the rain storm furnishes the river with a much larger tribute of alluvial matter, than when it only washed in its descent the matted foot of the wilderness. Thus the Don, like a cautious and insidious monster, throws out before it two immense feelers of rushes as piloting its track of ruin; and layer by layer, as brick by brick the fabric rises to completion, steadily and fatally the bottom of the bay rises to the surface.

I am sure I average lightly, when I estimate the deposit in the bay from two to three inches annually, less about the shores but more in deep water, and in the immediate outset of the Don. We must not be deceived into security by the little apparent change of depth about the shores. In such security the mischief will come upon us simultaneously. The grand deposit and filling up is yet in deeper water where the action

of the wave is not felt, for it is easy to perceive that the land boundary of the bay is the same now as it was when the harbour was first formed, and yet one-half of it has already become a vast delta of the Don ; and of what remains of the western bay, there is only at its deepest part 29 feet, where originally there was at least 15 fathoms.

By agitating the surface of very turbid water in a concave vessel, little or no deposit will take place at the borders, and powdered chalk may be added under the same operation until it is filled up, yet the whole surface will remain liquid to the last.

At the extremity of the upper wharf, which is 700 feet long, there is 8 feet 10 inches water— 1,210 feet from the shore in the same direction, there is 15 feet 8 inches— 1,822 feet out gives 17 feet 3 inches, and 2,552 feet out there is 20 feet 5 inches. At the lower, or what was called Mr. Cooper's wharf, 680 feet long, the extremity of which, by his account, was laid down in 13 feet water, there is now 10 feet 4 inches ; 1,190 feet from the same, in the same direction, I find 16 feet 4 inches, and 1,802 feet out gives 17 feet 11 inches ; so that upon an average, in the harbour, 700 feet from the shore there is 10 feet water, and 1,200 feet out 16 feet of water; after that 100 feet in distance does not yield one foot in depth, and where, upon an old survey I find six fathoms, or 36 feet laid down, I now only find 29 feet. I state all this to show that the great deposit is in deep water, where it escapes observation. These distances and soundings were accurately taken on the ice this year, 1833. I should also remark, that the word "peninsula" and "island" is used indiscriminately for one and the same thing, the island being alternately one and the other.

When the peninsula first rose out of the lake, the Don fell into the bay, nearly about the middle, consequently the first operation of its alluvial deposit was to cut the bay in two, leaving the deepest water east and west. But as the prevailing winds were west, and the bay was open to the west, it followed that the outsettings of the Don were naturally driven east, and its disgorgings first choked the passage in that direction, and of course it flowed where least impeded, that is, west. But now the process has arrived at that period, by the constant washing of the west wind, sweeping the island sand and gravel against the marsh and outset of the Don, that it has formed all round the head of the bay a beach sufficiently elevated above the marsh to form a complete dyke, with the exception of the mouths of the Don. Dams may be thrown across these without difficulty, and the Don, a little elevated, would soon work itself a passage through the marsh to the outlet at Ashbridge's Bay.

But, if through negligence, or want of observation, the harbour is abandoned to itself ; if, by some freak of nature, the waters of the western bay find passage by the mouths of the Don, and easy egress to the lake by the now extended outlet at Ashbridge's Bay, then I say, adieu the western harbour, adieu the Bay of York ! No longer heavy outset, the sand beats in, the shoal at the entrance lowers but spreads, the channel fills, and the Harbour of York becomes a large shallow sandy bay.

It has often been suggested to open a channel into the harbour from the east, through the neck of the peninsula and marsh, or immediately into the Bay of York, at what is called the portage. Without any local interest, but that of the benefit and preservation of the present port, I shall take the liberty of intruding my opinion also upon this subject, for any value it may possess.

As regards the cut at the portage directly into the Bay of York, I never entertained the idea ; for the shore on the lake side is so steep, falls so suddenly into deep water, is composed of loose shifting shingle stone, and the seas of the easterly storm so range along it, that any obstruction thrown out in the shape of a pier would only create an arm of the beach around it.

As to the entrance at Ashbridge's Bay, and through the marsh, which might be done, I apprehend, were it accomplished, it would in no way compensate for the difficulty and expense of the undertaking ; and without great judgment and knowledge of effect, in managing the water communication betwixt the two bays, I fear the channel of York Harbour would sustain serious injury by the event.

The mischief to be apprehended, supposing the communication to be made, would be this :—

When a lengthened period of the easterly storm had risen the waters of the lake at the west end, and consequently filled the Bay of York, and the wind shifted to the west, lowering the lake again, the waters of the bay would naturally make an effort by the nearest outlet to follow the level of the lake. But here, at the mouth of York harbor, met and dammed back by the fresh west wind, the superfluous water, instead of forcing its way to windward in under current, as formerly obliged to do, it would be drawing off to leeward, and transvasing *(sic)* into the eastern bay, to the prejudice of the present channel. The same mischief would occur on the rising of the lake *during* the easterly gale—the water would prefer filling the bay from the east, *with* the wind, than from the west against it; also to the prejudice of the western channel. In both these operations, and in all operations that multiply the outlets from the Bay of York, the present channel has everything to lose and nothing to gain.

And what should we not risk in the event? A harbour, upon the banks of which the town is already built, and one possessing every nautical requisite—such as a basin of perfect safety within—and excellent roadstead without—and easy access to both! And for what?—For a doubtful entrance upon a bleak and exposed coast; to track through a sluggish canal, imbedded in a sickly marsh, to get a second entrance to a good land-locked harbour at the value of ten minutes or a quarter of an hour in time to any steamer.

I have not neglected to examine the opening into the lake from Ashbridge's Bay, which I think an important one, and confirms me in the opinion I have before expressed, that as the land to the east wore away, and left the peninsula exposed, in the event of time it would assume the form of a *Presqu-isle*. I think the opening, when I examined it in the winter, was nearly one hundred yards wide; and from no ice being formed there, nor at some distance within, at a time when it was elsewhere thick, I should say the channel was seven or eight feet deep; but I had no opportunity of sounding. It is apparently protected by the projecting land to the north-east; but this is only apparent, for the easterly sea has actually made the breach. That the lake is here encroaching upon the island is beyond a doubt. It has made its way so far as to undermine and throw down a long line of trees of many years growth, which have all fallen their heads into the lake. Here, if any prospect should warrant the expense, an experiment might be made by piling the sides of the entrance to stop the further progress of the breach. If that should succeed, there is so large a surface of water yet within the eastern bay, that a flux and reflux caused by the varying levels of the lake, might produce a good navigable channel; and the use of a dredging machine to cleanse the marsh, increase the surface and deepen the water, would thus make a good harbour for local or private purpose; but I trust the experiment, without well weighing the consequence, will not be tried to make two outlets to the harbour of York.

To sum up my opinions, the channel should be contracted—the destroying cancer of the port (Don) eradicated—and the dredging machine freely used. This done, the channel will deepen of itself, the existence of the port be indefinitely prolonged, the waters of the bay be more limpid, and the bay itself, washed by every wind, encircled by a clear and healthful beach, so to remain as long as human industry and intelligence lined its shores.

Otherwise, in a very few years the east end of the town will be totally faced by a marsh; vessels that can enter the channel will not find sufficient water at the wharves; and the wharves bridged out to any particular distance will not find sufficient water for the vessels.

And now, in calling the attention of the country to the perishable condition of York Harbour, I put it to the country, whether the preservation of one of the four great portals to the commerce of Upper Canada on Lake Ontario, can be looked upon in any other light than public duty? Its local interest is so merged in the public good, that it cannot suffer without inflicting a public injury. Thousands may preserve, but millions will not construct such another port!

If, after maturely weighing my opinions, they are found to be correct; if I have shown the ruin of the port to be not far distant in the vista of futurity, the province cannot look with apathy on the scene, the inhabitants of York will scarcely line the banks of

its beautiful basin, reap the golden fruits of its commerce, be sensible of its decay and insensible to the claims of posterity : there is nothing British in the thought!

CAPTAIN BONNYCASTLE'S REPORT

ON THE PRESERVATION OF THE HARBOUR OF YORK, UPPER CANADA.

The peninsula opposite the southern face of the Town of York appears to me a much more ancient formation than is generally imagined. It is composed of sand in various states of cohesion, the surface being usually disintegrated, and increasing only in firmness and tenacity as it increases in depth.

It is, probably one of the many ridges of the bottom of the vast lake which existed before the present Ontario and Erie were formed out of its drainage ; nor has the shape of this peninsula materially altered for a vast length of time.

The French entered the basin and fancied it a river when they first explored the country, under the guidance of Hennepin, and the oldest surveys show little or no difference in its outline.

It is not necessary however with the object at present in view, to enter into a geological disquisition to prove that the peninsula was made during the sedimentary deposition of the tertiary periods ; but it is useful to that purpose to ascertain that it is not comparatively new, or in the constant habit of receiving great accessions to its bulk and extension.

The opinions entertained as to the best method of making the space contained within this natural barrier to the storms of the lake answer the purpose of a secure and effectual harbour for the larger steam vessels, as well as for the small but deeply-built schooners used on this lake, are to be divided into three general propositions.

1st. That of damming up the western estuaries of the Don River.

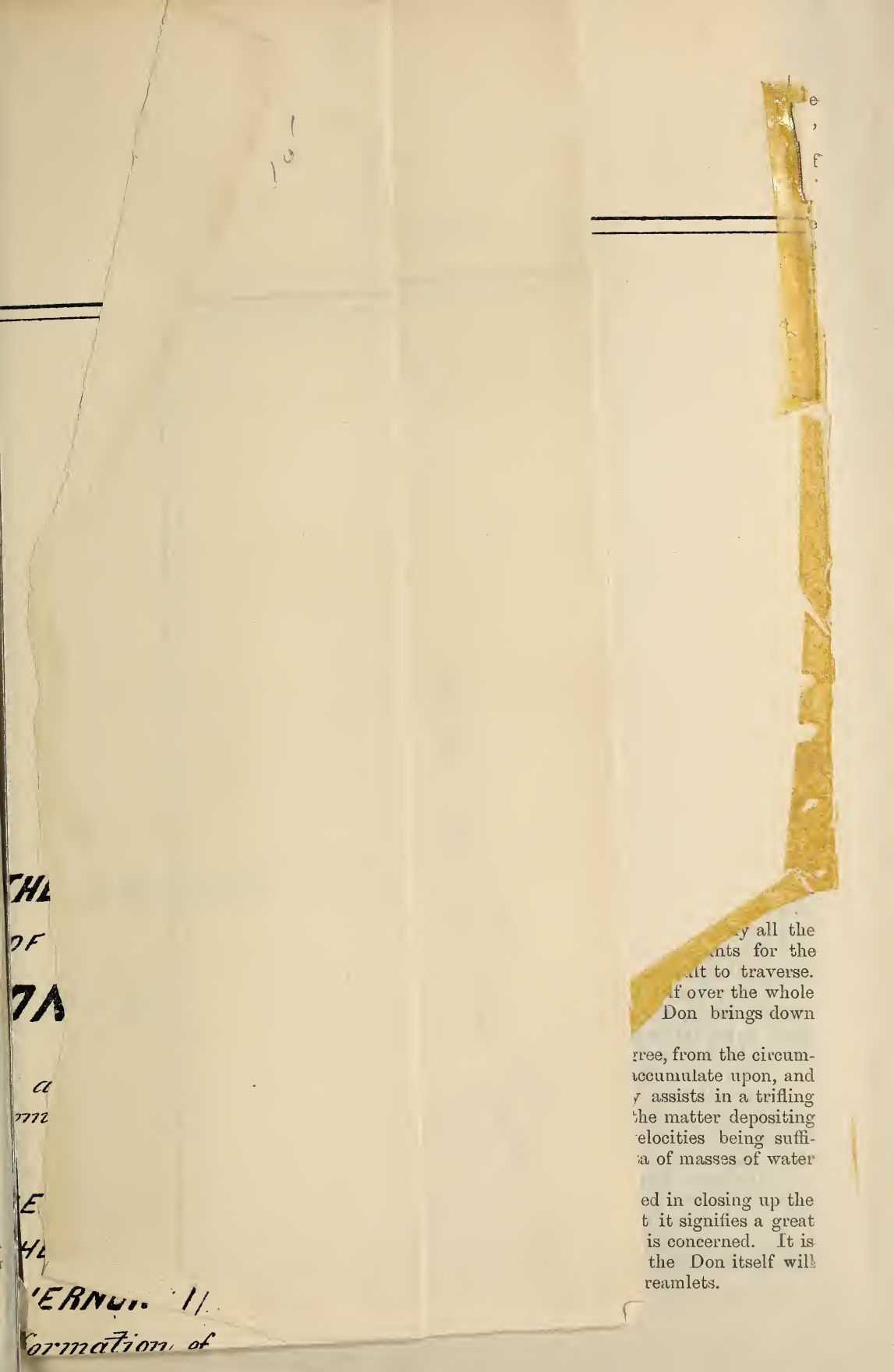
2nd. That of cutting a navigable canal through the narrows of the peninsula to the eastward, or near where it joins the great marsh.

3rd. The project, partly executed, of forming a pier or breakwater on the north shore of the channel at the Garrison, and converging the entrance by another breakwater over the whole length of the shoal from Gibraltar or rather Blockhouse Point, to the buoy.

Before entering upon any of these debateable topics, it will be as well to state something concerning the most material facts which experience has taught the geologist of the powers of the aqueous agent in destroying and renovating.

It is a well known circumstance that almost all the streams and rivers of this part of the country run over lands whereon either limestone is the denuded rock—and that that limestone is frequently in a great state of disintegration—or that their beds are cut through mud or clays containing a large proportion of the carbonate of lime.

The oxygen of the atmosphere acts on the bare rock as strongly as the solvent power of the water does on the mud and clays, and every stream is, therefore, well supplied from the alkaline and calcareous portions with the usual carbonic acid of almost all other rivers.



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Now this, it has been stated, is a lapidifying principle which in time will convert the deposit of the Don and the minor streams into a gradually hardening mass, which must, by continual additions, at length fill up the basin.

With this powerful agent acting, as it always does forcibly, the Don, the banks of the coast, and the blown sand from the shoal are supposed to be constantly uniting their assistance towards destroying the harbour.

But it should be recollected that, when any of the particles of rocks and earths are a part of the volume of moving waters, a large portion of them, if the water moves swiftly, are, by their size and acquired powers destroying the sedimentary beds at the bottom of a river, or of a basin where the water is subject to considerable motion, almost as fast as they are laid down.

But sedimentary beds are not so easily and quicky deposited as many are apt to imagine, for any one who has dabbled a little in Natural Philosophy—and especially those beginning to acquire a knowledge of Mineralogy—need no arguments to convince them that there are very few rocks that have a specific gravity greater than three times that of water, consequently, all earthy matter mixed with the moving waters lose, on an average, more than half their imaginary ratio of ponderosity. Thus, the quantity of matter subsiding, either from the flow of the Don into the bay, or from the currents which set in and out of the harbour with the usually strong winds from the westward or eastward, must be inappreciably small, considering that the action is violent and almost constant from the latter cause ; particularly any deposit in the basin from the Don, whose velocity is nothing compared to the currents.

On the other hand, we are not too hastily to suppose that the Don brings down less and less matter every year as the country becomes disforested, because, the more its banks are cleared and cultivated, the more the oxygen of the air will act on the newly exposed clays and rocks and earths, and the greater will be the deposit in its waters, to say nothing of the artificial necessary drainage of the arable soil. It will, however, be readily believed by those who know the locality that the Don transports little else than fine sand, mud, and vegetable matter in a state of comminution, and as it is a known law that the finer the atoms in suspension in a fluid are, the longer they are in subsiding ; it naturally follows that whatever escapes into the basin from that river—which cannot be much—being previously lost in the great expanse of the marsh which has apparently been formed by the silt of the Don, must have very little power to sink, except in perfect calms, never here of long continuance, until it passes into the main lake.

A proof of this is that there is very little mud on the great shoal and to elucidate the cause still more, it may be as well to state that particles of lime and alumina subside very slowly in water, and the most ponderous of all earths—heavy spar, or the sulphate of barytes—requires several hours to precipitate when diffused in water, and when that fluid is in a perfectly quiescent state, as do proportionately the heaviest metalic minerals in cold water.

The marsh, therefore, bounded as it is by a belt of sand, receives nearly all the sediment from the Don which is deposited in the vicinity, and this accounts for the innumerable and shifting creeks by which that marsh is rendered so difficult to traverse. Shut up the eastern forks of the Don, and allow that river to spread itself over the whole marsh, a few years would suffice to fill up the marsh with mud if the Don brings down such a quantity of matter as is supposed it does.

The Don is, therefore, useful to the harbour in a very slight degree, from the circumstance of a great portion of its deposit finding a convenient delta to accumulate upon, and also because that portion of its sluggish stream which enters the bay assists in a trifling degree in keeping its waters in motion, and in drifting out in calms the matter depositing from the clay banks of the basin itself, and from rains, very small velocities being sufficient, by a wise law of nature, to keep the upper and central strata of masses of water in sufficient motion for this purpose.

I do not, therefore, augur so favourably of the results anticipated in closing up the breaches which the Don has made into the basin, nor do I think that it signifies a great deal whether they remain open or otherwise, as far as the harbour is concerned. It is indeed probable, that, when the country becomes more cleared, the Don itself will become very insignificant from the drying up of its little tributary streamlets.

But there is one purpose for which the shutting out the Don from the harbour would be eminently useful, and about which there can scarcely be much difference of opinion, that is, in reclaiming the great marsh of upwards of a thousand acres in extent, which is at present such a fertile source of unhealthiness to the city; but, as my present object is not to enter into the manner in which this can be done with most advantage, I think it not uninteresting to state that there would be no obstacles thrown in the way of a company desirous to effect this object, and it is probable that it would well repay the projectors.

We now arrive at the discussion of the 2nd proposal, that of cutting a navigable canal through the narrows of the peninsula.

If this should be done without due consideration, the barrier which nature has interposed for the preservation of a harbour formed probably by the cutting action of the Don, when it was a larger river, which only requires a look at its banks to convince one's self what it anciently was, will be thrown down, and the harbour entirely destroyed.

The reasons to be assigned for this opinion are as follows :—

The southern face of the peninsula, a low ridge of sand, is bordered to some distance out, excepting near the Narrows, by large and fluctuating shoals, well known to the fishermen who have so recently established a profitable trade on them.

The force of the easterly and westerly gales on these shoals and the bounding shores is tremendous, as every person in York has frequent opportunity of hearing, even at the great distance the Town is from them.

Should a navigable canal, without due restrictions, be cut through the slender belt which divides the waters of the lake from the basin, all the millions of tons of large shingle, small rounded and angular fragments of granite and other hard rocks—which line the beach —will be put in motion; will break down by their erosive powers any barriers opposed to them; will carry before them the whole extent of the Narrows, and perhaps penetrate through the ponds, fill the basin, and convert it into a fresh sand bank.

To do all this, as well as to sweep in the *detritus* of the continually falling high cliffs of Scarborough, will not even require the force of the gale of the 5th of November, 1832, when the *Great Britain*, a steamer of the largest class, sought shelter there, under what was then a windward shore, from apparently inevitable destruction. For it is to be remembered that it is a fixed axiom in hydrostatics that a velocity of moving water of only three inches per second cuts down and moves off fine clay; six inches, sand; twelve, small gravel; and three feet, stones of an inch and more in diameter. Three feet a second is only two miles an hour, therefore in a heavy gale of wind we may readily suppose that even the lowest stratum of the moving fluid there, where most friction is, must travel at that comparatively small rate, and what would then the central mass of the superficies rage (*sic*) at in even common hard gales, straightened by the slender bounds in which a canal would confine it on that bleak and exposed shore. It might, in fact, tear away all the strip of beach along the western or bay shore of the Great Marsh, and let the whole of that body of the mud of ages into the basin.

It is argued that all of this may be avoided by running out extensive piers into the lake and forming a strong embankment along the Ontario face of the Narrows.

These, if placed in such situations as to break off the strength of the easterly and westerly swells, will do much towards it, but it will be also necessary to make the canal of stone, to puddle its sides to a considerable thickness or extent, to make it narrow and to place gates both at its entrance and exit.

With these precautions there can be no harm in trying the experiment.

But will these precautions, supposing they can prevent the filling up of the sides of the piers and canal, prevent the sedimentary deposit which the highlands and the coast beyond it are continually sending at present in that direction of the wind, forming new shoals outside the pier ways? This is a question well worth considering.

At present whatever comes into the harbour with its waters in easterly gales, or even in westerly ones, is I conceive now as long as it has only one entrance, taken out again before it has time to subside, and is spread over the vast expanse of Lake Ontario, and it is even very possible that the waters of the Humber, which move with some rapidity, accelerate its depression, for to them and to the great arm of the Humber which once flowed

past the Garrison, may be, with every show of reason, attributed, the singular cresent shape of the narrow ridge and shoal at the western extremity of the peninsula.

I have traced the waters of the Humber carrying large logs in a contrary direction to the wind, nearly opposite the old French Fort.

It is, therefore, to be feared that a navigable channel at the Narrows, unless formed as above mentioned, could not be kept clear, and steamboats and large sailing vessels would scarcely be tempted in strong gales, either from the eastward or westward, and certainly not from the southward, to run the risk of shipwreck on a shore lined under water with shoals of shingle and stones, to get into a pierway over which the sea at such times would break in mountains.

The difficulty of getting into narrow pierways in blowing weather is well demonstrated on Lake Erie, where at a similar exposed place vessels have often much difficulty to avoid striking the piers instead of running straight into the harbour—and sometimes suffer wreck upon them.

I do not, however, think that much difficulty will be experienced in forming the canal with the restrictions I have mentioned, and it will be useful in letting vessels out of the harbour, and in the transport of wood, lime, stone and other bulky materials.

We now come to the third proposition, that of contracting the present mouth of the harbour, so as to obtain a greater force of under current to keep the channel clear.

Part of this object, originally designed by Mr. Richardson, than whom no other person navigating this lake has a better knowledge of the harbour, has been executed by a very liberal grant of Parliament for the preservation of it, under the eye of the projector, from a plan given to him from the Royal Engineer's Office, which, it is somewhat to be regretted, although preserved in the outline, direction and emplacement of that part of the breakwater already executed, has been deviated from so materially in the internal structure as to render it no longer the same, so that, should it ever occur that any accident happens to it, it is hoped the Department consulted on the occasion, and whose views were known to be connected with the military defence of the position, will incur no blame ; and I, therefore, take this public method of relieving myself and those under my direction from all future censure, the more particularly as the Ordnance yielded their ground and rights most readily for the public benefit on so important an occasion. I beg leave to exonerate Mr. Richardson from any designed participation in the alteration of the plan which received the assent of the House, as he did not profess to enter into its details when it was given to him, from what he considered the proper and legitimate source—a source equally interested with the public in the preservation of the harbour, and whose acknowledged rights had to be yielded before it could be put into execution at all.

It is to deprecate the undue interference of one of the Commissioners with an established plan and estimate, connected as it was with the public service, both civil and military, that I have thus somewhat digressed from the main object of this Report, and to relieve myself and the Department under my charge from all future responsibility.

The breakwater has been carried out from near the Garrison, in a direction to resist the effects of the ice and the heavy gales as much as possible, to a distance of 800 feet from the shore, which contracts the channel at the entrance of the basin to about 850 feet between its extremity and the buoy.

This has, however, been proved not to carry it into sufficiently deep water to make it available as a pier, and it is proposed by Captain Richardson to increase its length until nine feet nine inches, or ten feet, depth of water is gained, for which purpose he has again applied to the House.

The breakwater was erected under several difficulties, but had also many circumstances in its favour, particularly the unusual lowering of the lake in the autumn of 1833.

Its utility is already evident ; the currents in the mouth of the channel have been surprisingly increased, and we have had, this last winter, the extraordinary occurrence of the inner channel being kept open nearly half way down to the lower wharves, in the most intense frosts, and whilst the rest of the basin was bound in solid ice.

It is, however, only a part of the suggestion for contracting the mouth of the harbour, and to complete this proposed end it will be necessary to carry a breakwater from Gibraltar or Blockhouse Point, 1,000 yards in a direct line towards the edge of the shoal.

Before, however, this breakwater is undertaken, it would be essentially necessary to consider whether the contracting the mouth of the harbour would materially assist in keeping the channel clear, also what effect it would have on the shoal, and the danger to be apprehended from the ice being retained longer in the bay, as has been supposed, and its being violently pressed against the pier in strong easterly gales.

It will be recollected that in the commencement of this Report, it is stated that some persons had imagined that the deposit in the basin will, in time, become hardened, and at length become lapidified, from the causes therein explained, and one great reason assigned for this notion is the state of the shoal itself, which is a loose sand where it is above water, and gradually gets harder and harder in proportion as it increases in depth below the surface, becoming, in fact, what is commonly called hardpan, or a species of inferior sandstone mixed with shells. This, however, I imagine, in the eyes of a geologist, so far from tending to prove the probability of the bay becoming filled with a hard series of deposits, tends to prove only that the shoal is very ancient, that it was the bottom of a former lake which covered all the countries of central Northern America, and that it has undergone the same process which is now constantly going on in Lakes Superior and Huron, whose great depths afford sufficient pressure and ample development of the necessary agents for solidification.

It has also been stated that, if this breakwater be thrown out, it will ultimately cause the destruction of the end of the shoal at the buoy, by the contracted volume of water undermining its edges; but it will be necessary, in obtaining proof of this assertion, to have clear evidence that the velocity of the current in and out, in easterly and westerly gales, is very great, as well as to convince the reasoner on these subjects that the under strata of these currents, and that which meets the bank at the surface and sides, has the power and force of the upper central portion of the fluid of the channel, which is contrary to all known laws, and to the actual state of the case, for the shoal at its extremity, where it bounds the channel, is what nautical men call *steep-to*, and is so hard and firm that it is doubtful if a much greater force would tear it up than the trifling one exerted by the lake in a comparitively land locked situation.

The form of the edge of the shoal is the best answer, however, to such doubts, for with all the force of the south-westerly winds, not an atom moves from Blockhouse Point to the buoy, excepting the loose sand and mud near the surface, which is torn off by the superior strength and force of a vast expanse of water lashing against and bounding over it.

Now, it is a known axiom that, where the volume of moving waters is augmented in, or as the whold fluid mass is increased by, the diminution of the exit or channel, so its velocity increases, and thus a smaller portion of the moving mass is kept back by friction against the sides of the passage. The channel of the bay being, therefore, confined to the space which nature has pointed out for it, will always tend to prevent the bottom silting up, and there will be little danger of the side of the hard shoal falling in to any alarming degree, and, even if it should evince signs of destruction—as its extent is very trifling—a solid face of timber being applied to it would obviate all difficulty on that head.

The narrowing of the channel would possibly have this good effect—and a very important one it would be—it might remove all the mud which at present spreads over the bottom, and uncover the rocky platform itself, thereby rendering the harbour accessible for a larger class of vessels than those which can now use it, and by causing a more powerful influx and efflux of the waters it will give the sedimentary matter held in solution less time to settle, and carry it further out into the main lake, where the disturbance of the level from powerful winds creates currents which it is well known spread that matter far and wide.

The more contracted the entrance of the harbour, the greater will be the rise and fall of the water within in easterly gales, which, from a well known cause, fill the basin much higher than the strongest westerly storms do, provided, however, always, that no other permanent outlet is made, or rather that, if the canal at the Narrows is made, that it be closed at such times by strong flood gates.

If this is kept in view as a main feature in any future operations, the less will be the deposit itself, for as the motive force of the fluid increases—by a known law—the

ratio of the difference between the progressive motions of the upper and lower strata decrease, in great velocities becoming almost nothing, and neither the magnitude of the bed, nor the slope of the bottom, changes this proportion when the mean velocity remains the same. All danger, therefore, of the harbour channel silting up within, from the action of the water over the shoal being nullified by the erection of a breakwater appears to me unfounded with respect to the retention of the ice in the harbour for a longer period in spring than it usually remains ; if the breakwater is erected, it has been stated that it would probably be the cause of shutting it up for an inconvenient period, that it would proportionately alter the climate of the town, and that it would perhaps tear away part of the new pier.

To all these assertions, experiments could alone afford a test, but I was inclined to believe, from the great rise and fall of the water in the basin during the prevalence of the ordinary winds which affect it and are almost constant in the spring, from the comparative thinness of the ice, which rarely begins to form here until January ; from attentive observation of the very loose and yielding nature of it near the mouth of the channel and almost down to the King's Wharf, owing to the shoals on each side, as well as from the great heat of the sun in this latitude in the spring, that there would be but little foundation, in the opinions of those who argue that the ice would operate against an experiment not in itself of a costly nature—for nature herself has nearly completed it—and which would, perhaps, prove so extremely beneficial to one of the most important harbours in the province.

The ice seldom packs on the shoal, and we have witnessed last year in a violent south westerly gale, on the 13th of January, that nearly one-third of the bay lost the whole of the ice from a wind blowing into the harbour, on which ice,—much more solid than it was the preceeding year,—people were crossing and skating, and a vessel was solidly frozen in the day before, notwithstanding too, the idea so generally expressed at the time that the pier, even in its then unfinished state, would retain it as long as the winter lasted. The ice on the weather side of the pier remained firm, in defiance of the fury of the waves, and it is not a little curious that this outer ice was formed in so exposed a situation long before that on the inside and generally tranquil expanse sheltered by the pier was made.

The experience gained by the spring of 1833 was favourable to the formation of the breakwater, as the currents were increased by the new pier to the extent of destroying and carrying out the ice, even against the wind.

The experience of this winter has been still more favourable ; the pier has been nearly completed before the harbour was frozen, and we have witnessed the good effect of the increased force of the currents on the deep water far into the harbour, the channel having been kept open during the most severe frosts, for the first time, perhaps, in the memory of man.

To know the strength which the current has acquired, it will only be necessary to state the following fact, witnessed by several respectable persons : The *Canada* steam packet, in the early part of the winter, tried to land her goods and passengers at the end of the new pier, during a very strong south-westerly gale, and got a warp on shore for that purpose, but, although the wind was blowing on to the pier head so strong, the current running out against the wind acted so powerfully upon the deep and large surface exposed to it by the vessel's sides under water, that it forced her out again and broke the warp.

If, however, this breakwater is to prevent the bay ice from floating over the shoal. it is possible to build the bay side of it with such a slope that in an easterly wind it will slide over it.

It is not, however, altogether the easterly winds which drive the ice out of Toronto Bay. The currents rushing in so forcibly in the western gales raise the level of the water under it, and then either their own cessation, or the usual effects of the easterly winds, prepare it to go to sea, and a great deal of it sinks and goes out with the under current.

The effect this year of the rising and falling of the whole body of ice in the harbour has been extreme, owing to the great thickness of it this winter, and has been disastrous at the lower wharves. Nothing however should of course be done permanently with out serious reflection, and I feel very much inclined to believe that it would be very advisable to consider whether it would not be prudent first to put a stop to a serious evil

which has not been so generally noticed as it should have been, the wasting away of the clay bank near the Garrison, only partially protected by the new pier, and which every frost and thaw adds to.

This has filled up more of the borders of York Harbour, than all that the Don has ever done at the bottom.

A similar cause, that of the destruction of the banks from the windmill to the Market Place, was most probably the reason why the water shallowed at the oldest wharves in the town and is still shallowing at them.

The numerous drains and sewers, and the quantity of rubbish daily thrown into the bay, is another cause, the latter having the two-fold effect of lessening the depths near the shores, and rendering the neighborhood very unpleasant in the best part of the year.

The Harbour of York is of the greatest importance, both in a military point of view and in relation to the commercial prosperity of this rising city, and should in no way be neglected.

It may be thought presuming in me to offer an opinion on the subject, but, having been called on last session for scientific information on the subject by the Committee of the House of Assembly for the improvement of the Harbour, I may, perhaps, be permitted to suggest that in any contemplated works the whole basin should be taken into consideration, and none should be proceeded with until it is made sufficiently clear by the united opinions of several competent practical judges, that they will not interfere with the improvement of the whole.

The nuisances so loudly complained of during the past season of sickness and visitation will perhaps never be effectually checked until a continuous quay, similar to that recently made at the King's Wharf, is built along the whole extent of the city, from the steamboat wharf to the Garrison, and which is at present more particularly required where the rushes grow in front of the Parliament Buildings, and where the bank is so rapidly wasting away in front of the new portion of the city, works far from being of an expensive nature, estimates having been already made of them, and essential to the safety of the basin and to the salubrity of the city.

Having thus drawn up a few leading observations on the proposals which have been made to improve the harbour, I shall merely now state thereon :—

1st. That there can be no harm in making a small canal at the Narrows shut in by flood gates and protected by piers ; that it will be very useful for the purposes of trade, and that under these restrictions no obstacle will be thrown in the way.

2nd. That it would be highly advantageous to the city that an attempt should be made to drain the marsh, and dam up the mouths of the Don.

3rd. That it would be still more important to the public, and essential to the improvement of the Harbour, that the breakwater at the entrance should be fully completed at both sides, for which a sum of from fifteen hundred to two thousand pounds currency would be sufficient, with an additional five hundred for a road and rails, and for removing a rock at the entrance.

All of which is respectfully submitted, this Report being drawn up and made under the commands which His Excellency the Lieutenant-Governor has been pleased to give that I should act therein, in meeting the civil engineers appointed to examine and report on the Harbour.

R. H. BONNYCASTLE,

Capt. 1st Royal Engineers, Western District.

York, Upper Canada,
14th Jany. 1834.

APPENDIX.

Having had time since giving in the above Report, to examine and consider upon the project for draining the marsh, I have further to report that, as the levels of the marsh appear favorable, I should consider that the best possible mode of effecting the

LAKE ONTARIO

THE MAYOR & CORPORATION

added 12th March 1835

SCALE

PART OF THE CITY OF TORONTO

HARBOUR OF TORONTO

Sand Ridge

These Ponds are deep and do not change except about here

Marsh

Rushes all along

Lighthouse

Sand

Marsh dry season Sandy Marshy

Blockhouse Bay From 3 to 5 ft of water

Sturgeon Sand

rushes

This sand shoal is very hard

Great Shoal

Gibraltar Point

rushes

Harbours or Portage

Shoals

The Proposed Canal Deep water

Good Anchorage deep water

Part of Marsh of 1000 acres

Numerous Channels & Ponds full of ponds & arms of the Don

Sandy ridge with trees

deep Asbridge's Bay

Proposed line of Canal 3¾ miles from new bridge over Don

By canalling the Marsh here it will be drained and good materials had for embankments

River Don

Don Bridge

Rushes along the shore

Keating's Wharf

Ewart's Wharf

The King's Wharf

Old Navy Office

Proposed Esplanade

Front Street

Market Street

King Street

Queen Street

Richmond Street

Adelaide Street

Wellington Place

Government House

Reserve for Government House

Private Residence

Upper Canada College

General Hospital

Osgoods Hall

Spadina Avenue

Brock Street

Bathurst Street

Portland

Toronto Street

Yonge Street

Bay Street

York Street

Simcoe Street

Victoria Street

Church Street

Jarvis Street

Sherbourne Street

Parliament Street

Ontario Street

Niagara Street

Caledonia Church

Proposed Breakwater

Channel

Sand

Old French Fort Toronto

Western Battery

Garrison

Military Reserve

Hall Spring

Brewery

The creek has a fall of 84 ft 6 inches from this Bridge to the Lake

Concession Road not yet formed

Beach Shore Road to Niagara

Upper Road to Niagara

(Copy) J. O. H. King Capt. R.A.

GEO. E. DESBARATS PHOTO-LITH MONTREAL.

drainage of it would be by canalling the Don River through the said marsh, by which that object would be gained and a more favorable site obtained for forming a canal than at the Narrows.

I also beg to remark that, in making the sewers for the city, it would be very advisable to construct one main sewer through the whole length down to the marsh, instead of lateral ones into the bay.

R. H. BONNYCASTLE,
Capt. Royal Engineers, Western District, U.C.

Toronto, U.C.,
26th March, 1835.

(*Appendix QQ, 11 Vict., 1847.*)

REPORT

Of the Commissioners of Public Works, laid before the Legislative Assembly, 12th January, 1847.

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TORONTO HARBOUR.

No appropriation has yet been made for this harbour. It appears that Mr. Gzowski was instructed by the late Board of Works to make a survey of it, which was done sufficiently to establish the fact that the entrance is rapidly becoming narrower; but no estimate was made for the construction of works to prevent (if possible) the further progress of the bar towards the shore. The Commissioners recommend that a careful survey be made, with a view of furnishing an estimate for a remedy, to prevent what is much feared by many will be the case, the rapid contraction of the channel to such an extent as to prevent vessels entering at all times with safety.

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(REPORT OF C. S. GZOWSKI ON WORKS UNDER HIS CHARGE.)

Engineer's Office,
Toronto, 4th May, 1847.

* * * * * *

TORONTO HARBOUR.

Instructions were given to me by the late Board of Works to make a survey of this harbour, by reference to which it will be observed that a bar exists at the entrance of the harbour, and which is making in a north-westerly direction.

From the data that could be obtained from several masters of vessels, who have certain permanent land marks (now existing) to guide them in coming in and going out of this harbour, it was ascertained that within these last seven years the bar has made a distance of 280 feet, and narrowed the channel to 250 feet.

There can be no doubt that the making of the bar is caused by the wash and drift of sand from the southern portion of the peninsula, which is carried when the wind is from the east, and which, from the want of sufficient current from the bay, when the wind changes from the west, is not carried out, but remains, forming the bar referred to, and which, if not prevented by the construction of works, and increasing and confining the current, will very soon destroy the entrance to the harbour.

The increased trade to and from the harbour demands that some steps should be taken to secure and render the ingress and egress permanent and safe, and I beg leave most respectfully to suggest the propriety of ordering an examination and survey to be made of the harbour, which should be accompanied with plans and estimates of improving it effectually, and in a mode which, from the examination, and from inquiry from the naval men who have watched the different changes and alterations, may be found most advisable to adopt.

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C. S. GZOWSKI,
Engineer.

(*From the "Daily Colonist," Toronto, 8th February, 1853.*)

TORONTO HARBOUR,

ENGINEER'S DEPARTMENT,
TORONTO & GUELPH RAILWAY,
TORONTO, 28th January, 1852.

HUGH RICHARDSON, ESQ.,
Harbour Master, Toronto.

SIR,—Having reference to your letter of the 14th ult., requesting me to furnish, for the information of the Commissioners of Toronto Harbour, "An Estimate of the cost of extending the Queen's Wharf westward, and to report on the state of the channel and the improvements required," I have the honour to comply with your request in submitting,

Firstly.—My opinion as to the nature of the obstructions which already damage the entrance to your harbour, which, if their progress be not arrested, may in time entirely blockade it.

Secondly.—The best means adapted to improve the channel and prevent further encroachment of the bar.

Thirdly.—The system of construction to be adopted in the enlargement of wharf accommodation, and towards rendering a portion of the harbour alike available for winter and summer navigation

Fourthly.—A specification of the manner of constructing, and an estimate of the cost of the work necessary to bring the proposed improvements into effect.

My acquaintance with the locality under consideration has been short, but even as a stranger I could not, standing on the deck of a steamer passing into or out of the

harbour, fail to be struck with the narrowness of the limits which the buoys placed along the front of the shoal assign as the width of the channel available for vessels drawing no more, perhaps, than eight feet of water, or without thinking it to be deplored that there should be so scant an entrance to so fine a bay. Again, looking from the shore, when the waters are beginning to be ruffled by a coming gale, or subsiding into calm after one, I have frequently viewed, with an engineer's eye, the plainly defined outline of the bar, indicated by a white muddy shoal, whilst the waters on either side of it are clear and uncoloured, its most northerly "spur" showing a startling proximity to the city side of the bay.

Such casual observations, united to a knowledge of the shifting nature of the material comprising the peninsula, have led to the conclusion that the process which created the singular beach separating the bay from the lake is still in active operation, and if not checked by artificial interference will continue to operate to the increasing detriment of the navigation until the communication between the present harbour and the outer waters shall cease to be available for the passage of vessels.

The notes which you shewed me of your own observations for the past (20) twenty years, and the soundings taken by you from time to time during that period, proving that the bar has advanced across the mouth of the harbour at an average annual rate of about (19) nineteen feet, until there now remains scarce (200) two hundred feet of channel, tend to confirm me in my preconceived opinions. That the evil is created from without seems to me equally clear, the sand bank being simply the accumulation of the deposit brought down year after year by the Humber, the Etobicoke, the Credit, the Sixteen, and other streams discharging into the lake above the city, all of which are subject to great and sudden freshets, the discoloration of their waters at such periods indicating that they are surcharged with the *debris* of the regions they have traversed, which, held for some time in suspension in the lake, is, by the prevalence of the south-westerly winds, drifted down and finally precipitated along the "peninsula" which forms the southern shore of the bay, and over the still submerged bar, which is fast becoming its western one.

To the effects of the counter currents, caused by the prevailing winds being down the lake, and the River Don discharging its waters in a contrary direction, I believe is due the origin of the peninsula which encloses the bay, the precipitation of suspended matter naturally taking place on the neutral line between the two conflicting currents, and so well assured do I feel that this vast accumulation of deposit is mainly attributable to the action of the above named streams, that it would surprise me much if a scientific examination of the bar should fail to prove the particles entering into its composition to be representatives in miniature of the same geological formation as obtains along and below the Flamborough Heights.

That the silt should go on accumulating in an increased ratio as the channel contracts is not unlikely, and were the operations of nature left unmolested "to work out their own destiny" in this case, it would be by no means far fetched to imagine that there might be those now amongst us who would live to see their grandchildren walk dry-foot from the Old Garrison to the outer lighthouse.

While the lake and its tributaries are united in the work of blockading the entrance of your port, there is a less potent, but insidious and patient enemy busy at its eastern extremity—the River Don—bearing down every spring vast quantities of rich alluvial silt from Scarborough Heights, to find a final resting place in Toronto Bay, and so surely as it has formed hundreds of acres of land between that and Ashbridge's Bay, so surely will it continue to work out the same mission to the detriment of the former, until the hand of man shall interfere to give another direction to its labours.

Doubtless the evils to be apprehended from the action of this stream are distant and insignificant as compared with those to be remedied at the entrance of the harbour; but having more than once heard the opinion expressed that an effect beneficial to the channel, in aiding to keep it unobstructed, is due to the influx of the Don water, I wish here to record my dissent from such opinion, being convinced that the bay is the recipient of, and "cess-pool" for, most of the matter carried down by the Don, and that the natural currents which do exist at seasons, and check the more speedy formation of the bar, are to be traced to an entirely different source.

Next, as relates to the remedies to be applied to prevent your singularly fine bay from degenerating into a mere muddy lake, the DREDGE presents itself as the prominent agent by which a channel of the requisite capacity must be maintained. It might be that, for some years to come, you would not be driven to employing it, but many years cannot elapse before the Harbour Commissioners *will have a powerfnl steam excavator most constantly at work;* and I believe that a considerable saving in the ultimate cost of preserving to Toronto Bay its rank amongst the harbours of Lake Ontario will be effected by bringing the operations of such a dredge to bear upon the rapidly contracting channel within two years from the present.

As an auxiliary to the dredge, and to give a concentrated effect to the currents which set into and out of the harbour periodically, according to the variation in the level of the lake, as easterly gales prevail or subside, I would recommend that a certain width of channel be permanently defined by constructing along the point of the shoal, but in deep water, (even though the point has to be cut away to make room for it) a pier, or break-water, of timber "cribbing" filled with stone.

This structure should have its eastern extremity about opposite the lower end of the Queen's Wharf, its front line to be far enough out to leave at least 400 feet width of channel between itself and the line of 11 feet water "in shore," and it should extend "out to sea," taking the first about a south-west by west, and then a nearly due south-west direction until completely clear of the "spur" of the shoal, beyond which it should be carried some hundreds of feet into navigable water.

This pier, which would constitute the southern boundary of the channel, would, in my opinion, have the effect, an eddy being created around its point, of causing an accumulation of sand to take place *behind* it, rather than in the channel, tending to make the bar develope itself *above* water, the sand continuing to accumulate over the bar as it now does, and outside of it, along a line produced from the point of the proposed pier to the outer lighthouse, until the peninsula would have completely formed round the mouth of the bay, leaving open only the 400 feet channel reserved at the entrance of the harbour. The ingress or egress of the water, as the lake rose or fell beneath the varying winds, would thus be restricted to a narrow avenue, creating a current which would be likely to have the effect of supporting the operations of the dredge, in carrying away the loose silt from the bottom of the channel.

The effects of the dredge will be *certain*, and, therefore, indispensable, and it can in some degree be made to bear its own expenses by the material excavated being applied towards filling up the "water lots" in front of the city, a work, speaking of the *whole front*, which it will take many years to accomplish.

The construction of a pier, such as above described, would be to a certain extent an *experiment*, but, even should it fail in *entirely* answering the intended purpose, I feel satisfied it would still be of essential service to the channel, if acting only as a guide for vessels, whereby, with the aid of a light on either end of it, they could enter or leave the harbour, the darkest night, in perfect safety; and the limited width of the channel, preserved of a certain depth by dredging, whilst the bar is still accumulating without, could scarcely fail, as already observed, in creating currents which would tend to sluice away much of the material loosened by the action of the dredge.

Dealing in generalities, as I am in this report, I cannot now suggest any plan that strikes me as so likely to succeed in making and maintaining a good entrance to your harbour as the joint one here laid down, possessing, too, the advantage of being feasible within the limits of moderate expenditure.

Before proceeding to speak of the system of improvements to be adopted in the enlargement of wharf accomodation, I will, with your permission, having already professed myself inimical to the operations of the Don, say a few words as to how, in my judgment, its obstructive tendencies might be effectually met and counteracted. The positive evils to be dreaded from that quarter are too distant, likely, to call for any action in "our time." I shall, therefore, not dwell upon the subject beyond simply giving a hurried outline of my views.

The Don should be prevented altogether from discharging itself into the bay, to effect which I would cut a canal from some point below the bridge into the lower bay (Ashbridge's) at the same time making an opening through the peninsula opposite the

mouth of the canal, or, as it would then be, the river, so as to give the waters free egress to the lake. I would divert the stream into this new channel by throwing a dam across its present "debouchment," or if necessary right across the lower side of the bay. The distance from the new mouth of the river across Ashbridge's Bay would be, comparatively speaking, so short, that the current would be likely to retain its full force, so as to carry away most of the silt into the outer lake, and at the annual period of freshets would have the effect of sluicing the opening so as to keep it always clear and free from an undue accumulation of sand. Another effect likely to be produced would be the forming of much deposit from the floods of the Don in rear of the dam, thereby tending to raise the low lands in that vicinity, until perhaps a considerable width along the margin and fronting the harbour would be available for building or other purposes.

The important object of improving and preserving the existing communication with the lake will be sufficient to engage the attention of the present generation, particularly as the damage accruing to property from the gradual filling up of the lower part of the harbour is not to be sensibly felt for many years to come; but beyond a doubt the time will come when the Don will not be permitted to pour its turbid waters into Toronto Harbour; and when some such scheme as that here suggested will be carried into effect. I attach a sketch of the harbour, on which I have marked in *red*, the sites of the contemplated works.

* * * * * * * *

The last subject to be considered, though the first in importance, is the cost.

1. In order to obtain a width of channel equal to 400 feet, with a least depth of water of 11 feet, it would be necessary to cut away the point of the shoal to the extent of about 15,000 cubic yards. The pier, or breakwater, which I have recommended, should not be less than 1,200 feet in length.

1,200 feet of breakwater,
15,000 cubic yards of dredging.

* * * * * * *

Before concluding, I should like to touch upon another question, one of very great import to Toronto Harbour, but to which, my attention not having been directed by your letter, I did not think it necessary to allude in the body of my report. I speak of the project of cutting a canal through the narrows of the peninsula.

The very great advantage to be derived from having an eastern outlet to the lake will probably keep this subject so constantly before the public that the experiment will, ere long be tried, more especially as the breach which has lately occurred would seem to have taken the initiative in the matter, and "pointed out the way."

The making of such a channel will be a simple matter of *cost*, and once made, a short time will serve to show whether the advantages accruing from it will be sufficient to counterbalance the expense of maintaining it. I have termed it an "experiment," and such I believe it would be in the widest acceptance of the term, being doubtful that the problem of what its effect on the harbour will be can be satisfactorily solved beforehand. It may prove immensely detrimental to the Bay in drifting in vast quantities of silt and shingle; or it may fail to accomplish the end intended, in simply working out its own destruction, by "silting" up more rapidly than the dredge could free it. None, I think, will deny that one or other of these results is amongst the probable contingencies waiting on the experiment in question; and, though I have not given the matter the attention necessary to enable me to pronounce confidently on the above points, I must record my opinion that the new channel would certainly not be a self sustaining one, and that its effects upon the present entrance would be the reverse of beneficial.

In concluding this report, I would beg leave to remark that my opinions are founded upon general observations only. Owing to a protracted absence from the city, your letter of the 14th December was not received by me until within the last fortnight, and, even had I not been limited to time in reporting on the question referred to me, I was not

authorized to incur the expense that would have attended the instrumental examination necessary to a more detailed and minute investigation of the subject, in which every citizen of Toronto may be said to possess a direct personal interest.

I am, Sir,

Very respectfully yours,

W. SHANLY.

(*Canadian Journal, 1853, Vol. I*).

REVIEWS

TORONTO HARBOUR.

1. *Report by Walter Shanly, Esq., C.E., Toronto, Jan. 2nd, 1853.*
2. *A Report by Sir R. Bonnycastle, 1834.*
3. *A Paper read by S. Fleming, before the Canadian Institute. Toronto, June 1st, 1850.*
4. *A Supplementary Paper read by S. Fleming, before the Canadian Institute. Toronto, March 22nd, 1851.*
5. *A Letter published in "The Patriot," signed "Kiwas Tully." Toronto, February 10th, 1853.*

"In a multitude of councillors there is (or ought to be) wisdom." Mr. Shanly's Report, lately published, has had the effect of directing general attention to the condition of the Toronto Harbour, upon the efficient maintenance of which undoubtedly depends the commercial character and prosperity of the city. The subject is one, therefore, of very general interest; and as, in an engineering view, it is moreover admitted to be of very great difficulty and danger, it is of importance that opinions given authoritatively should be subject to rigid scrutiny and frank reviewal. If we should find it necessary to dissent from the views of the authors of the above papers, they must remember that these views have by their own acts become public property, and that the higher the source from which they have emanated the more worthy are they of criticism, even though it be adverse. Everybody who knows Toronto knows the peninsula by which its bay is nearly enclosed. Approach the city by water from what point he may, the stranger's eye rests upon this curiously shaped spur; and as he quickly discerns its sheltering properties, and to it attributes the excellence of the haven, so charmed is he by the stillness of the waters within, and so satisfied in his mind by the contemplation of an evident security, that he generally fails to lament the narrowness of the entrance or to speculate upon the theory of that formation which is the cause of it. Some there are of course who, like Mr. Shanly, "stand-

ing on the deck of a steamer" or "looking from the shore" have noticed "the plainly defined outlines of the bar," which alas! it requires not "the eye of an engineer" to discover. Nay, some grumbling and visionary alarmists have been looking at it these twenty years past; and although indulging in fearful predictions in regard to its future (in which they have been supported by engineers, surveyors, *et hoc genus omne*, from the time of General Simcoe to the present day), have failed to attain a hearing, far less to induce a belief. "Truly," have explained these disappointed savants "men are no prophets in their own country!" and therefore when Mr. Shanly asserts that his acquaintance with the locality has been "short," and that his knowledge of it is that of a "stranger," he takes his course with the acuteness common to his countrymen, and "goes in to win," on the acceptation of the same old proverb, extended to a belief in prophets from afar.

Before attempting to prescribe a remedy, engineers, like physicians, generally endeavour to ascertain the cause of the evil; and, having satisfied themselves that the root and manner of its action have been discovered, they proceed to apply those preventive or remedial measures which they believe to be suited to the case; but of course if the premises be erroneous the deduction will be false, and the applications made upon it will very probably be unsuccessful.

This gives great importance to the inquiry, "How has the peninsula been formed, and to what causes may the prolongation of the bar at its western extremity be ascribed?" Upon a clear and satisfactory determination of these points, probably depends the efficiency of the remedial measures; in its absence any measures so intended can but be experimental, and may be worse than useless.

Prior to 1850, four different theories of formation had been proposed, which we find thus enumerated in Mr. Fleming's paper of that year:—

1. That the peninsula is an accumulation of drift carried across the lake by the current of the Niagara River.

2. That it has been formed, and that the shoal at the entrance of the harbour is now in process of extension, by the influence of the opposing currents of the Don and the more westerly rivers, *in contact*, and the deposition of matter on the neutral line between them.

3. That it is a ledge of the rock underlying Toronto and the lake forming a check for the deposition of and now covered with alluvial matter.

4. That it is a deposition of the tertiary period. And,

5. That it is jointly a delta of the Don, and a drift from the eastward.

The first of these propositions may briefly be dismissed as untenable: the third is at variance with the general geological features of the locality, and has been disproved by investigation; and the fourth is that suggested by Sir Richard Bonnycastle, who states his belief "that the peninsula is one of the many ridges deposited at the bottom of a vast lake which existed before the present Ontario and Erie were formed out of its drainage," "and that it had probably not changed its form or character since it emerged from the waters." Now, by reference to the papers and charts in the possession of the Canadian Institute, we find that since Bonnycastle wrote, not only has the general outline of the peninsula been very considerably altered and extended, but that at one particular point an area of upwards of thirty acres has been added to that previously within the shore line; and as this recent addition is in geological character a perfect *fac simile* of the portions anterior to it, we may infer that both are due to the same causes, and traceable to the same source, and therefore, that the peninsula is a formation of the present epoch and not a diluvian deposition.

The second proposition is that which has found a supporter in Mr. Shanly, who, after stating that "on looking from the shore, when the waters were beginning to be ruffled by a coming gale, or subsiding into a calm after one, he has frequently viewed, with an engineer's eye, the plainly defined outline of the bar, indicated by a white muddy streak, whilst the waters on either side of it were clear and uncoloured"—proceeds to record his opinion that "the sand bank is simply the accumulation of the deposit brought down year after year by the Humber, the Etobicoke, the Credit, the Sixteen, and other streams discharging into the lake above this city; all of which are subject to great and sudden freshets, the discolouration of their waters at such periods indicating that they are surcharged with the *debris* of the regions they have traversed, which, held for a

time in suspension in the lake is by the prevalence of south-westerly winds, drifted down and finally precipitated along the "peninsula" which forms the southern shore of the bay, and over the still submerged bar, which is fast becoming its western one."

"To the effect," he continues, "of the counter currents, caused by the prevailing winds down the lake, and the river Don discharging its waters in a contrary direction, I believe to be due the origin of the peninsula which encloses the bay, the precipitation of the suspended matter naturally taking place on the neutral line between the conflicting currents; and so well assured do I feel that this vast accumulation of deposit is mainly attributable to the action of the above named streams, that it would surprise me much if a scientific examination of the bar should fail to prove the particles entering into its composition to be representatives in miniature of the same geological formation as obtains along and below the Flamborough Heights."

In this proposition then, Mr. Shanly first declares that "when the waters are beginning to be ruffled by a coming gale, or subsiding into a calm after one, the bar is denoted by a white, muddy streak, with the water on either side of it *clear and uncoloured.*" Now, we presume that as "the discoloration of the waters of the Humber and other westerly streams indicates that they are surcharged with the *debris* of the regions they have traversed," the absence of this discoloration on the margins of the bar (and especially under the circumstances stated) would appear to denote that such *debris* has not been carried thence, and by those waters; for how could "the waters on either side" remain, even during a gale, in a translucent state, if at the same time they were the vehicle of transportation for the discolouring matter referred to, and in other places so apparent? But in the process of such a transportation a distance varying from five to twenty miles, and a depth of water varying from *sixty to one hundred feet*, are involved; and it seems very questionable, if it may not be stated as an impossibility, that the materials of which the peninsula is formed (*sand and gravel*), could for such a distance, and over such a depth of comparatively still waters, be "held in suspension and drifted down" to their present position. Were the deposit of an argillaceous nature, and did the winds prevail from the south-west, there might be some grounds for such a supposition; but, as neither of these is consistent with fact, we conceive there are none.

Again, in a subsequent paragraph (and after having attributed the bar to "the effect of *the counter currents* of the lake and the River Don") Mr. Shanly says, whilst the lake and its tributaries are united in blockading the entrance of the port, there is a less potent but insidious and patient enemy busy at its eastern extremity—the River Don. "Doubtless the evils to be apprehended from the action of this stream are *distant and insignificant;* * * * but having more than once heard the opinion expressed that an effect beneficial to the channel, in aiding to keep it unobstructed, is due to the influx (we presume *efflux* is intended) of the Don water. I wish here to record my dissent from such opinion, being convinced that * * * *the outward currents which do exist at seasons are to be traced to an entirely different source.* Now, the Don seems to be a very fickle or very accommodating river. First, we have its current conflicting with the lake waters at the bar, *and thus forming it*, and then we have it insidiously retiring to "the eastern extremity of the bay," and "busy" in another service. First it is described as discharging its waters "at the bar," in a contrary direction to that of a south-westerly wind, and immediately afterwards "the outward currents are attributable to an entirely different source!" Far from attempting to disentangle this mystery, we shall not even essay to determine which "current" of this conflicting argument is the true one. Indeed, we are inclined to doubt both, for if the outward current be not due to the Don, it must, we suppose, be due to the wind; and if to the wind, inasmuch as its influence would be common to both currents, simultaneously impelling them in the same direction, there could be no "conflict." A wind driving the lake waters west would drive the bay waters out, and westerly; whilst a wind impelling the lake waters east would drive them into the bay, and thence easterly. We cannot understand the proposition, and should be glad to see it explained.

But, it is said that "the conflicting currents" (we mean of the waters, not the argument) result in "a neutral line, where the precipitation of the suspended matter actually takes place." One current, however—that of the Don—has been unceremoniously dismissed to "the eastern extremity of the bay," and the other, and that the most potent,

is attributed to the influence of the south-west, which is certainly not the prevailing wind : as surely, therefore, as the wind changes, the neutral line between the two currents (for we must recall the Don to get the conflict) changes with it, and hence the precipitation is distributed far and wide, or is chiefly in the line of the prevailing wind, and, therefore, not where it is said to be.

There are other and very cogent reasons inducing us to doubt that the peninsula is the deposit of the streams to the westward, or (as Mr. Shanly suggests) "the geological representative in miniature of the Flamborough Heights." We believe the peninsula to be, in superior geological formation, the representative of the *Scarborough* heights, and if so, then undoubtedly it is a deposit from the *eastward*, brought, not as Mr. Shanly says, by the River Don, for that would involve a geographical impossibility, but by the lake waters, under the influence of south-easterly gales. And again, before the commencement of such a deposition as that suggested from the west, the Don, it is fair to infer, must have had a free run into the lake ; when, therefore, it conflicted with a stronger current from the west, it must have been turned easterly ; and as the neutral line would of course, take the same direction, the deposition would have been easterly also. Now, the current of the Don outwards has been turned westerly, and the deposition, it is admitted, has been and still is westerly ; it is reasonable to conclude, therefore, that the strongest lake currents have been from the east—and if from the east, then undoubtedly the peninsula cannot be a deposit from the westerly streams. Besides, to suppose that the deposit has been from the west is to suppose either that the two currents first met at the bar, and that the deposition has been *thence easterly* or that they met at the eastern limit of the peninsula, and that the deposition has been *thence westerly*, in the teeth of the strongest current : but the former is contrary to fact, and the latter an impossibility : we have, therefore, to account in some other way for this formation and its progress.

And this brings us to the fifth proposition in Mr. Fleming's list, and to the consideration of his papers named in our heading.

Mr. Fleming contends that the peninsula is jointly a delta of the Don and a drift from the eastward. This theory he has propounded after a very complete and apparently a very accurate instrumental survey of the bay and the peninsula, including soundings within and without, and sections from various points of the city front on lines southerly through the bay and peninsula to the lake. He has, moreover, transferred from charts of various dates the form and condition of the peninsula, by which, in connection with his own more recent surveys, he professes to elucidate the manner of its extension and to these he has appended charts of the other natural harbours of our lakes, where, in his opinion, the same agencies have been exercised to a similar result.

Many of our readers will remember the occasion on which these papers were exhibited some two years since. The authorities of the city—the Mayor, and members of the Corporation, the Harbour Commissioners, and others officially interested in the subject—were invited to be present, and some of them did attend the reading of the papers, and the discussions which ensued upon them, in the rooms of the Canadian Institute. We think we are correct in saying that the general impression then was that Mr. Fleming had succeeded in establishing the truth of his propositions ; at any rate, it is certain that the valuable information which he had collected was acknowledged to have given the first practical direction to this important inquiry. Our limits will not permit us to make any very lengthened reference to Mr. Fleming's labours, nor is it necessary, as in combating Mr. Shanly's views we have in a great measure adopted those of Mr. Fleming. He contends that the ground-work of the peninsula was a delta of the Don, formed on the subsidence of Lake Ontario from a high to its present level, and the consequent scour of the region now represented by its valley :—that this delta has afforded a base for the drift from the highlands of Scarborough, which formerly occupied a much more southerly position than at present ; and that under the influence of the south-westerly gales, it has continued to augment, the deposition being westerly, until, in approaching the open waters of the Humber Bay, its course has been turned towards the north.

The direction in which the drift is moved by the waves is subject, of course, to the direction of the wind ; and the quantity moved bears intimate relation to the force of the waves, which with winds of equal velocity, are again dependent for their power upon the area which they traverse. Now, we know it is beyond dispute, 1st, that the prevailing

wind of Lake Ontario mainly affecting its north shore is from the south-east ; and, 2nd, that the greatest extent of water over which any wind impinging on the north shore of the lake can traverse is also south-easterly, so that, inasmuch as the formation of the peninsula is identical with that of the Scarborough Heights, and the prevailing and most powerful winds precisely those which would carry the drift thence to the peninsula, we have very strong grounds for concluding that to those influences its formation may be ascribed. But, further, if we recur to the principle upon which Mr. Shanly rests his argument, that of a neutral line between two conflicting currents surcharged with *debris*, we shall find that it may be applied with more consistency in aid of this than of any other hypothesis : for let us again premise that the original run of the Don waters was free into the lake, and nearly (as the outlet of the stream still denotes) at right angles with the shore, then they have impinged upon the lake waters at a point opposite the outlet, and under the influence of the prevailing and the most powerful winds, have been turned westerly. The neutral line would of course take the same direction, and on the deposition alike of the *debris* from the Don, and the *drift* from Scarborough, would take place, until by that deposition the currents would be divided, the neutral line lost, but a base be formed upon which the extension of the peninsula would result in a westerly direction, and by the drift alone. In these suppositions there is nothing inconsistent with the ascertained facts of the case : indeed, we find that the surface of the peninsula is composed of a succession of ridges, all starting from the east, in curves adjacent and tangential, or nearly so, to the line of the south shore, but spreading and pointing towards the north-west : an effect clearly of the south-east wind, and proving that much is due to its greater power and prevalence.

Believing, then, that the formation has been and still is mainly, if not altogether, from the eastward, we might proceed to discuss the propriety of the measures suggested in view of the preservation of the bay channel from further encroachment. But we have already said that, "if the premises be erroneous, the deduction must be false," and, as the application of that law is common to all arguments, it may perhaps be better not to extend the criticism to those practical measures which we are inclined to think have been suggested in the absence of that full knowledge of the local conditions under which alone works of so important a character can be prudently undertaken. We cannot, however, conclude without briefly expressing our regret that in such a case (it matters not from whence the evil comes) the dredge should be referred to as *a permanent necessity*, for in that view it generally has been, still is, and, we think, always should be, the dread of an engineer. Always a costly expedient in harbour channel works—except as the remover of some standing and purely local obstruction—the pioneer of a scour—or of some equally permanent remedial or preventive power—it is temporary in its results, endless in its application, and, accordingly, the *dernier resort* of the engineer. It is often easier and more economical, *always* more satisfactory, to divert a drift than to remove it ; and he must be a patient practitioner, indeed, who, having dredged a bar, stands by during the deposition of its successor to renew the process.

In the heading to this review we have named Mr. Tully's "Letter" as being one of the documents recently submitted on the subject ; as, however, the consideration of the others has more than covered the ground which it occupies, and as, in relation to the formation of the peninsula, it professes no novelty, we shall refrain from any special notice, and merely express our satisfaction that this question has at length forced itself upon public notice, and attracted even gratuitous inquiry amongst professional men.

REPORT BY H. RICHARDSON

TO THE COMMISSIONERS OF TORONTO HARBOUR.

GENTLEMEN,—

In making a report of the state of the harbour, one great feature in it will be the result to be expected from the present breach by the lake at the Narrows.

There have been two breaches into Ashbridge's Bay, also last year, all communicating with the harbour, and all acting as waste weirs, to the prejudice of that current to which it owes its navigable channel.

Upon the faith of this current the extension of the Queen's Wharf was advised, and although it is as yet only constructed half its length, a widening of the channel has already taken place. By accurate measurement with a float line, on the 20th October, it was found to be widened 30 ft. Much of this is due to the violent action of the steam-boat wheel in so narrow a channel, the recoil of the waves from the wharf, and the strong current caused by the reaction of their displaced water.

* * * * * *

I have reason to believe that much of the sand from the bar has washed in from the west during the present opening of the Narrows, as I have been obliged to shift a white marking buoy much further to the east than where I first laid it down in the spring, to mark the eastern limit of the shoal water of the bar.

The close noting of the rise and fall of the water in the bay by a float and index shows it to be scarcely two days alike, or even twelve hours; fluctuating from *one* to *four* inches according to the wind. This is taking it at Gorrie's Wharf, which serves as a mean in the bay. And when the wind is strong south-west, and it shows a rise of three or four inches, it will be double that at the head of the bay, and this wind, depressing the lake on the outside of the peninsula, will account for the violent current which is observable out at the breach during strong westerly winds.

The lake has risen during the summer twenty-four inches, and fallen twenty-nine inches, being five inches lower than last year at this time, showing that the water is falling.

I will now give you an opinion on the effect the new opening at the Narrows may have upon the harbour if allowed to continue. I will first precede it by a few remarks on the acknowledged effect of currents upon sand; and as the southern and western boundaries of the port are composed of that material, a synopsis of the laws by which sand is accumulated and dispersed may not be irrelevant to the understanding of the subject.

It is estimated that sand loses three-sevenths of its weight under water, and that a current moving at the rate of 600 yards per hour will remove fine sand; at two-thirds of a mile per hour, will put in motion coarse sand, and a velocity of two miles an hour will transport stones of two inches in diameter.

Sand deposits are the *debris* of continents and islands, conveyed to the bottom of the ocean and lakes by the agency of water; and sand bars, sand banks, and sand shoals, are but the existing monuments of present and former currents.

To the action of water is due the formation of Toronto Harbour, and the same power that formed it can destroy it.

Sand bars accumulate where the action of currents cease, or where counter action commences,

The bar across the mouth of bay is formed by the south-west wind driving the water into the bay, and the reaction by the under current to restore the equilibrium, by which reaction the sand of the bar is held harmless to the harbour in its position, whilst the broken water on the top of it acts as a dam, and forces the surplus water to seek a passage by the north shore; hence the navigable channel.

I am well aware that, to a generality of observers, the idea of a current in this harbour appears absurd, yet, to the eye of a geologist, indications of a current are everywhere apparent. It is not necessary that the motion of water should be seen to produce its effect, any more than that of a ball from a charged musket. Suffice it, that water,

ever liable to have its level disturbed, whether by the action of the wind, the flowing of rivers, or the tide wave, the immutable laws of equilibrium require a counter current to restore it.

The object of this dissertation upon sand and currents is to show that, where alterations take place in the currents of a harbour bounded by sand physical alterations in its form *must ensue ;* and where *artificial alterations* are contemplated, the action of currents cannot be overlooked, nor their effects miscalculated, with impunity.

Taking in view the construction of the port, and having for a long series of years made close observations on the forces and agents that are working its decay, I have adopted the following as axioms of my belief :—

1st. That the integrity of the peninsula is essential to the preservation of the port.

2nd. That the bar is essential to it as a harbour, otherwise it would be but a sandy bay.

3rd. That a current through it from west to east, by tending to remove the bar and flood the harbour with sand, would be destructive to it.

The present conformatiou of it we owe to ages of nearly uniform action of winds and currents ; but the time has arrived, by this breach in the peninsula, when this uniformity must undergo a change, and it will be found that a novel current in a port whose boundaries are sand will soon alter the physical features of it.

A short personal examination by the eye and sounding staff of the effect produced by this breach of scarcely twelve months' duration will give some practical insight into that which I am predicting. As early as 13th August last, in company with Mr. Tully, I measured and sounded it.

It was then 140 feet wide, a dry bank of sand stretching inwards on each side like piers ; the westernmost was 115 feet long above water, and the whole bank 100 feet more under water, with only two feet upon it, making, in all, a bank of sand 215 feet by 140, *within the line of beach*, where, in the spring, there was 12 feet of water ; and now it is shooting down into deep water like making a causeway. I think it will be found that there was upwards of 12,000 cubic yards of sand thrown in at that time.

The greatest mischief, I apprehend, has taken place on the south side of the bar and harbour, but, for want of any recent survey or plan of it, alterations, as they take place, cannot be noted for future guidance.

If the boundaries of the harbour were rock, stone, or even slate, the current through it, as well as a navigable channel to the east, would be invaluable to the commerce, as well as beneficial to the health of the town, but, being of sand, unless known physical laws be suspended for the especial benefit of Toronto Harbour, *a current through it will accelerate its ruin.* The only substitute for this want of current throughout is to encourage the strongest possible flux and reflux that the prevalent south-west winds can create.

Suppose the cross beach that separates Toronto and Ashbridge's Bays were removed, it would give a range of between five and six miles to the south-west wind and wave. With this wind there would be, when high, a constant and strong upper and under current. This shows the necessity of preventing all egress of water to the east, which must injure the under current towards the west.

I will here simply state my opinion on the effect that a canal 200 feet wide and 12 feet deep at the Narrows would have upon the harbour. During a strong south-west wind it would cause such a strong current over the bar, and along the south side of it (judging from the effect as now seen at the beach) as not only to deluge the harbour with sand, but in a short time to sweep away Blockhouse Point and all the inequalities of the north side of the peninsula and convert the harbour into a wide mouthed bay, at the expense of the east end of it first.

In regard to a current through the harbour, what must appear an anomaly is that the north-east wind (the breach open) scarcely creates other current than that produced by the local effects of the sea rushing in, whilst the south-west wind creates a destructive one from west to east.

The cause is simply this : the north-east wind so raises the water of the lake to the west that the pressure is inwards over the bar to fill the bay against the wind, as shown by the rise of water by the gauge, whilst with a strong south-west wind the water is blown into the bay, over a wider surface, and again locally rises as proved by the gauge,

whilst the lake is by the same wind depressed at the west, hence the current through the harbour from west to east, and observed with such violence during the whole of a strong south-west wind at the beach.

With the peninsula intact, all gales are favourable to the channel, and maintenance of the bar. During a breach in the peninsula all high winds are more or less destructive to the harbour.

There are so many agents at work upon it that I am afraid almost to enumerate them. The continued breaches in Ashbridge's Bay since the great one in 1832, the present one at the Narrows, bringing in mounds of sand; the wearing away of the peninsula in the centre, as shown by the long line of aged trees undermined by the lake from Ashbridge's Bay to Privats' Hotel, and forming a bay, the apex of which is the breach at the Narrows, into which the sea surges in all easterly gales; the various sources from whence the north shore of the harbour has filled up from four to five feet in a line with the old head of Cooper's Wharf in the course of 20 years, and the channel contracted from 800 to 350 feet, and all the same causes existing with increased effect; the alluvium of the Don from a more cultivated country and looser soil, the minor streams, common sewers, and offal of a large, populous, and growing town, all discharging into the bay; add to these the cutting down of the banks, and carting soil into the bay, and even with all due precaution, the construction of the Esplanade will add its modicum to this list of evils.

But referring back some 50 or 60 years to an old chart of the harbour drawn by the late Mr. Chewett, upon a scale of three inches to one mile, or 30 chains to an inch, if correct, I find the channel was then 1,455 feet wide, from 12 feet water inshore to 12 feet on the bar, and the soundings marked in the channel are three and three and a half fathoms, and the spot where the breach into the bay at the Narrows now is, is marke of some breadth and covered with trees.

When, 20 years ago, upon close observation and reflection, I publicly asserted the harbour to be in an advanced stage of decay, 20 years later observation confirms my assertion.

The present breach by the lake at the Narrows is similar to the warning shock of an earthquake before volcanic eruptions, it forebodes coming events; and an irruption of sand into the harbour during some extraordinary gale may be found as destructive to it, as an irruption of lava to vineyards and villages.

The remedy here is prevention, by raising dykes, and securing the integrity of the peninsula.

Therefore, I call the most urgent attention of the Commissioners to this point, as immediately connected with the safety of the harbour.

The next are the necessity of dredging the channel and winter harbour; the repairs of the Queen's Wharf; and last, but not least needful, a survey and plan of the harbour, without which the Commissioners must work in the dark.

As my opinions are presumed to have influence here, and as I have expressed them freely on the subject of a canal, which seems to have enlisted in its favour all the interests of the east end of the town, it is but fair that they should be made public; that, if erroneous they may be refuted, and the public may have the benefit of hearing arguments against them.

I have observed that all opinions on the subject by scientific and professional gentlemen, have been given with a reservation in favour of their professional one, as to its physical effects on the harbour.

If the preservation of it be not duly appreciated now, I fear that before another 20 years elapse, it will come home to the inhabitants forcibly enough, that the value of property in the town is co-existent with the vitality of the harbour.

The pier completed, the channel dredged out to 14 feet deep, and 400 to 500 feet wide, and all breaches in the peninsula carefully stopped and guarded against, I have no doubt but the channel will remain in a good navigable state for some years to come.

The careful preservation of the harbour, in arresting the progress of its decay, by judiciously directing some and counteracting others of the natural forces which tend towards it; and by relieving it as much as possible from the evil consequences incident to the growth of a large town upon its shores, will require the vigilant and intelligent labours of a Commission. But whether such attention to the public interest can be

expected to be gratuitous is not for me to say, but I know and feel that, however fairly and diligently the dues may be collected, the judicious disposal of them for public benefit requires greater abilities and greater attention.

HUGH RICHARDSON,

Harbour Master.

Toronto, 12th January, 1854.

PREMIUM REPORTS ON TORONTO HARBOUR.

(The Canadian Journal, 1855, Vol. III., App.)

Under date 14th March, 1854, the following notice was issued:—

TORONTO HARBOUR.

The Commissioners of Toronto Harbour, having decided upon offering premiums for the best reports upon the improvement and preservation of the harbour, and appropriated the sum of £112 10s. 0d. for that purpose,and the Common Conncil of the City of Toronto having also voted a similar sum for the same object,

NOTICE IS HEREBY GIVEN

That three premiums of £100, £75, and £50, respectively, will be given for the three best reports on the means to be adopted for the preservation and improvement of the Harbour of Toronto.

Such reports to embrace the following subjects: The effects which have been produced, or are likely to be produced, by the present breach at the eastern extremity of the Bay of Toronto, particularly with reference to the bar at the entrance of the bay. If prejudicial to the harbour, suggest the best means of closing it, and of strengthening that part of the peninsula against further encroachments by the waters of the lake.

Furnish also a statement as to the probable cost of such works.

If, on the other hand, a permanent opening at that end of the harbour should be shown to be a benefit rather than an injury, furnish full particulars as to the best mode of making a canal, and the probable cost thereof.

Also, as to the advisability, or otherwise, of enlarging the opening between the harbour and Ashbridge's Bay, or by making a permanent opening into the lake, from Ashbridge's Bay, and the cost thereof.

The reports must be sent in not later than the 15th April next, addressed to the Chairman of the Commissioners of the Toronto Harbour.

Two copies of all such reports to be furnished, one for the Harbour Commissioners' Office, and the other for the Clerk's Office of the City of Toronto.

No 6.

Diagram to illustrate the First Premium Report

Harbour Entrance
The Flat water Line
TORONTO HARBOUR
The dotted Lines represent the longitudinal axes of beaches probably indicating more or less distinctly the epochs of Low Lake levels, during which periods sand bars were thrown up into beaches
LAKE ONTARIO

EDOUARD DESBARATS PHOTO-LITH. MONTREAL

Diagram to illustrate the First Premium Report

No. 9.

The only practicable outlet for a PERMANENT Canal.

Under date 1st April, 1854, the following announcement was made :—

TORONTO HARBOUR.

The period of receiving the proposed reports "on the preservation and improvement of the Toronto Harbour," is extended to the 4th of May.

The Commissioners desire it to be understood that it is not requisite that the reports should embrace detailed estimates of the cost of the proposed works, except in so far as will suffice to give a general idea of the comparative expense of the different plans proposed.

REPORT

ON THE PRESERVATION AND IMPROVEMENT OF TORONTO HARBOUR, BY HENRY YOULE HIND, M. A., PROFESSOR OF CHEMISTRY IN THE UNIVERSITY OF TRINITY COLLEGE.

(The first premium of £100 was awarded to the Author of this Report.)

The questions proposed by the Commissioners of Toronto Harbour respecting the means to be adopted for its preservation and improvement involve as a primary consideration the origin and distribution of the entire mass of accumulated materials from near the town line of Scarborough and York to within a few hundred yards south of the Garrison Wharf, thus embracing the whole of the sand and shingle beach enclosing Ashbridge's Bay and the swamps of the Don, together with the peninsula boundary of Toronto Harbour, and its westerly sub-aqueous extension towards the Humber Bay. Various theories have been advanced from time to time with a view to unveil the history of the formation of the Harbour. The citizens of Toronto are familiar with the names of Roy, Bonnycastle, Fleming, Shanly, Tully and Richardson, in connection with this important subject. The views of these gentlemen have been brought before the public in many ways, either in papers read before the Mechanics' Institute (Roy, published in the *Monthly Review*, June, 1841), the Canadian Institute (Fleming, 1850-51), or in the forms of reports and letters (Bonnycastle, Shanly, Tully, and Richardson). Allusions are also made to the encroachments of the sand-bar towards the Queen's Wharf in the reports of the officers connected with the Board of Works, and published in the sessional papers of the Legislative Assembly. Notwithstanding a discussion in which so many have taken a part, and which has extended over a period of fifteen or twenty years, the subject does not appear to be exhausted, and perhaps still offers room for additional speculations. It is essentially a geological subject, involving the purest active operation of those forces which, in a scale of greater magnitude, have recorded their existence and power on the shores of every tidal and tideless expanse of water. Nor can the preservation of the harbour, with any propriety, be considered apart from the limits of geological science; the remedial measures proposed would then resemble guesses at a remedy for an unknown and dangerous disease.

The President of the Board of Works, in 1844, reported to the Provincial Secretary that, "at the inlet of the Toronto Bay the sand is evidently making much, and I am of the opinion that at no remote period some work must be encountered to fix and preserve such an entrance as the rapidly increasing trade of that important city will require." In

1847, Mr. Gzowski reports (Sessional Papers, Legislative Council, 1847) to the Secretary of the Board of Works that, from the data that could be obtained from several masters of vessels, who have certain permanent land-marks (now existing) to guide them in coming in and going out of the harbour, it was ascertained that within the last seven years the bar had made a distance of 280 feet." Further on he observes, " there can be no doubt that the making of the bar is caused by the wash and drift of the sand and shingle from the *southern portion of the peninsula*, which is carried when the wind is from the east, and from want of a sufficient current in the bay, when the wind changes to the west is not carried out, but remains, forming the bar referred to, which, if not prevented by the construction of works, and increasing and confining the current, will very soon destroy the entrance to the harbour.

Of all the explanations which have been advanced in relation to the origin and progress of the peninsula boundary of Toronto Harbour and its sub-aqueous extension, the one which appears to me most complete, and, at the same time, most consistent with observed phenomena, in many important particulars, is that submitted by Mr. Sandford Fleming, C.E. Mr. Fleming's views have been fully explained in two papers laid by him before the Canadian Institute, and since published in the *Canadian Journal* (Vol. II., p. 105 and 223). It appears necessary that the adoption, wholly or in part, of any particular theory of Toronto Harbour, out of several which have been offered to the public, should be accompanied by satisfactory reasons for the selection. In accepting the main features of Mr. Fleming's theory, the writer cannot give assent to that gentleman's exposition of the early history of Toronto Harbour, or of the delta of the Don, or of the remedial measures for the preservation of the harbour. It is but just to add, however, that many important features of Mr. Fleming's explanations, which will be referred to hereafter, are thought to *involve* the true history of the peninsula as to its origin and development, the question of time not being taken into consideration. The views submitted in a report to the Harbour Commissioners that the origin of the peninsula is to be traced to detritus brought down by the rivers to the west of Toronto is completely set aside, first, by Lieutenant Herbert's chart of Lake Ontario, which gives a depth of ninety feet between the southern limits of the Humber Bay and the Lighthouse Point; second, by Mr. Fleming's measurements, which show a depth of sixty feet about sixty chains from the Garrison Common beach; third, by the direction of the prevailing winds and their influence upon the expanse of water exposed to them; fourth, by the impossibility of masses of sand and shingle creeping along the shore, in water sufficiently shallow for waves to impel them from the west, without leaving traces of their passage in the form of beaches and shoals; fifth, by the ponderous nature of the materials of which the peninsula consists, namely, shingle, pebbles, coarse felspar and quartz sand, and black magnetic oxide of iron* ; and, sixth, by the topographical conformation of the peninsula, which shortly will be described.

The geological conformation of this part of the country is altogether contrary to the supposition that the basis of the peninsula is an upheaval of the Hudson River Group, upon which shingle and sand have been deposited. The Hudson River Group extends from beyond the Rouge to the Credit, and forms the basis of the drift which covers the country. Its character in this neighbourhood is anything but persistent, as shown by the uniform depths to which the Rivers Don, Humber, Mimico, etc., have succeeded in cutting it. In its exposures in all the localities mentioned, including also the Garrison Common cliffs and the west side of the Humber Bay, it exhibits blue argillaceous shales, alternating with bands of calcareous sandstone, and occasionally limestone bands. Its descent into the bay and lake is gradual, and within a distance of 500 yards north of Privats' Hotel it is not reached at the depth of 30 feet.† The water worn shingle which largely enters into the composition of the peninsula contains occasionally fossils belonging to this rock, but they do not differ from those which may easily be found in the drift clay super-imposed upon it on the neighbouring shore, and which, during the deposition of the drift, have been washed out of some more northern exposure (see Geological Report for 1845, p. 88). That shingle of the Hudson River Group forms the base or foundation of the peninsula is

*See Note A, in Appendix.
†See Note " B " in Appendix.

quite possible, but it is more than probable that all the shingle found there has been transported to its resting place and had its origin in the drift clay of the neighbouring shores of the lake to the eastward.

Mr. Fleming separates the history of the Delta of the Don from that of the peninsula boundary of Toronto Bay, and he carries us back into the dim and misty ages of the quarternary period in order to account for the deposition at the mouth of the Don of its present delta. "Having thus," he says, "shown that sufficient time may be granted, the Don, therefore, supplies an adequate cause for performing, and completing long since the word assigned to it year after year during its early history, slowly but constantly hollowing out a channel and removing the former contents of its valley to the lake, the lighter and more soluble matter being held for some time by the water, to be distributed far and wide ; the heavier particles, on the other hand, to be deposited near its mouth in the form of an extensive shoal or delta—the base or ground work of the peninsula, on which again to be deposited a drift from other causes and from another source."

His arguments for the antiquity of the marshes of the Don to be hereafter alluded to, are so intimately connected with his views of the former probable extent and influence of the Scarborough Heights that it is desirable, before proceeding further, to examine the existing phenomena of that range of hills and cliffs, and see how they agree with the descriptions which have been given of them.

The following description of the Scarborough Heights is the result of a personal visit to that romantic and picturesque range of cliffs during the present month (April, 1854.) The Scarborough Heights consist of two distinct terraces, which run into one another on the farm of W. Crone, about nine miles from Toronto. These terraces attain their utmost elevation near Scarborough Tavern, (Gates'). The elevations of the terraces, as measured by Mr. Murray, the Assistant Provincial Geologist, are as follows :—

First terrace, above the lake	161 feet.
Second terrace, above the first	159 "
Second terrace, above the lake	320 "

(See Geological Report for 1845.)

As before remarked, these terraces run into one another on Mr. Crone's farm, that is to say, the second or highest terrace trends here so much to the south *that a portion* of it has fallen into the waters of the lake, as shown in Section No. 4. The slope of the second or highest terrace has been denuded by the fall of its materials to the extent of about 100 feet, so that the perpendicular altitude of this, the highest denuded portion of the Scarborough Heights, does not exceed 260 feet, upon the basis of Mr. Murray's altitudes, which for the total height of the first and second cliffs are the same as those given by Mr. Fleming, namely, 320 feet. About 60 feet of the cliffs of the second terrace still remain clothed with heavy timber, and have not contributed any materials to increase the deposition on the shore of the peninsula boundary of Toronto Bay. It is highly probable that the present generation has witnessed the fall of the first contribution of the second or highest terrace to the sand shoals of the lake, and it may confidently be asserted that 50 years ago the second terrace was separated from the first by a narrow plateau several yards in breadth, and consequently quite unaffected throughout its entire development in the Township of Scarborough by the waters of the lake. On the next farm to the westward, that of J. Thom, the second or highest terrace has been still less subject to the effect of the encroachments of the lake, and remaining portions of the first terrace can be seen forming projections in the sides of the crater like cavities produced by the land slips which have caused these extensive and destructive removals.

The next farm to the west belongs to D. Pherill ; there the second terrace is attacked to a very trifling extent, and the projecting remains of the first terrace are more distinctly seen. On the junction between the farms of A. Pherill and A. Ashbridge (the next succeeding to the west), the second terrace leaves the lake and retires into the interior, as shown in the diagram No. 2.

It thus appears that the amount of materials derived from the destruction of the second terrace is inconsiderable, and might be altogether embraced in a dozen gullies simi-

lar to that represented in fig. 3, which was sketched this spring, and of which there are great numbers equalling it in capacity, along the first or lowest terrace, between Gates' Farm and a mile or two to the east to the commencement of Ashbridge's Bay. Mr. Fleming's ingenious speculations with respect to the original form of the Scarborough Heights, and their relation to earlier developments of Toronto Harbour, as exhibited in his diagrams, numbered 9, 10, 11, 12 and 16, become imaginary, and the section No. 16 assumes the probable form exhibited in diagram No. 4, in one spot only ; the highest cliff contributing its materials to the lake, not exceeding 50 years ago the height of 160 feet. Although Mr. Fleming's account of the past history of the Scarborough Heights, and, as will be shown hereafter, of the marshes or delta of the Don, is not borne out by existing topographical conditions, yet it happens that its failure in this respect does not interfere with his views of the formation of the harbour in its *present* condition and development. The first or lowest terrace, from the nature of the materials entering into its composition, and its altitude (in some places 160 feet), affords abundant supply of detritus to explain the formation of the sand and shingle beaches constituting the peninsula boundary of the harbour and of Ashbridge's Bay.

The first terrace is composed of stratified sand and gravel, and of blue clay. In one of the gullies adjoining that represented in fig. 3, the following order of stratification was observed by the writer. The same order of stratification was frequently noticed along the cliffs of the first or lowest terrace :— *

Yellow clay and vegetable mould, about	2	feet
Stratified sand and gravel	16	"
Blue clay	25	"
Stratified sand	50	"

Blue clay and concealed measures to the waters' edge.

Diagram No. 5 shows the stratification in a gully near Gates' Farm.

A layer of two feet of small water worn boulders, from one to six inches in diameter, is very persistent about ten feet from the surface of the lowest terrace ; coarse and fine sand, beautifully stratified, occur in vast quantities ; in fact, the cliffs now present every requisite feature for rapid destruction.

They did not present these features fifty years ago, and there can be no question but that the operations of the settler have exercised a vast influence upon the recent rate of progress with which the destruction of the cliffs has taken place, and, (as a not very remote consequence) the alarming rapidity with which the peninsula boundary of Toronto Harbour has increased during late years. In 58 years, upwards of 30 acres have been added to the peninsula, in deep water beyond the lighthouse, on Lighthouse Point. The shoal towards the mouth of the bay has increased to a very threatening extent, and has spread in the direction of Humber Bay from Lighthouse Point ; a new reef is rapidly forming, which, perhaps this season, will effect a fresh addition of 10 or 12 acres to the western limits of the peninsula, as indicated on the map No. 6, and which only requires a period of low water to develop itself in the form of a beach. Now, all these enormous changes in so short a space of time imply the existence of no ordinary forces or supply of materials for they have occurred in deep water, and involve the removal of many million tons of shingle and sand.

It is now proposed to consider the relation of the Scarborough Cliffs to the existing peninsula boundary of Toronto Harbour, without entering into speculations, as yet, as to its early history. The problem is not difficult of solution, and it is thought to be one of the utmost importance, at it seems to lead at once to those remedial measures which the preservation of the harbour demands. It points to a power which has been slowly and beneficially acting for centuries, but which has suddenly become energetic and dangerous in its recent extension.

A stroll along the precipitous cliffs of the lowest terrace, from Gates' Farm to where the partial union of the two terraces takes place on Crone's Farm, then onward towards Toronto, within a mile or two of the commencement of Ash-

* Note C, appendix 11.

bridge's Bay, will enable the observer to comprehend the remarkable effect which has been produced by clearing the plateau of the lowest terrace of its forest growth, and thus laying bare the crests of the cliffs. The consequence of this complete removal of the protective covering of timber is that the cliffs, being unprotected for many years by fallen trees, have lost their former terraced and wooded character, and have become (by land slips) clean, bare and shelving, exposing their loose and shifting materials to all the effects of rains and winds. When the lowest terrace was wooded, every tree which fell from the crests of the cliffs, either hung by its roots or was arrested in its fall down the sides of the cliff by underbrush and small trees, and thus became a resting place for those annual slips of earth, trees, pebbles, and even sand, which the thaws of spring set in motion. By such means minor terraces were formed, supported by the stratum of blue clay before described, and on these subordinate terraces grass and shrubs grew and gave a permanent character to the sides of the cliff. In some of the gullies the retaining and conservative effect of underbrush is still well-marked, especially where the forest growth has been permitted to protect the crest; there are, however, but few instances now remaining on the cliffs, for miles have been cleared. Another rather singular consequence is to be found in the quantities of loose sand which are blown up by every gale of wind from the south, south-east, and east, from the bare sides of the immense crater-like gullies which have been formed during the last few years. A gentle breeze suffices to transport the unstable sand up the clean sides of the gullies on to the plateau above. In several instances the writer measured four inches in depth of coarse and fine sand, which had been blown up upon the stubble of last year's wheat. The sand frequently penetrates into the fields for a distance exceeding one hundred yards from the crests of the cliffs, and in the process of time will succeed in destroying, or at least very materially deteriorating, considerable tracts of land on the lower plateau, if not checked in its march. When the cliffs are denuded of their protecting fringe of trees, and, as a natural consequence, of the underbrush which shields their sides, the least streamlet of water rapidly loosens and sets in motion the sand and gravel which form so large a portion of the lowest terrace. The bed of clay arrests this process of destruction for a while, but, being itself underlaid by sand and gravel as unstable as that by which it is super-imposed, its conservative influence is of short duration, and in a thousand instances the bare and clean sides of enormous gullies show how rapid is the present progress of their formation and increase.

It is important to mention that occasional traces of long continued persistence are observable in some of the gullies. Beds of bulrushes of gigantic growth may be seen in some of those whose sides are still partially protected with under brush and small trees. These occur on the lowest bed of blue clay. The blue clay itself sometimes presents precipitous tower like prominences which are best seen east of Gates' Farm, where the forest still affords its protection to the cliffs. It is not, however, only the plateau and the cliffs which point to the destructive effects which have been produced by clearing away the timber; the beach itself shows by its encroachments how much its boundaries have been increased by the absence of that annual supply of fallen trees which once checked the inroads of the surges of the lake. In many parts the sand and shingle present the same features as those which distinguish the peninsula. Formerly the progress of the breaking waves was arrested by multitudes of those natural groynes which Mr. Fleming has so faithfully delineated and described.

The present high waters of the lake have of course exerted their influence in removing many of the trees which afforded long resting places for shingle and pebbles, but the absence of a continued supply of these protective barriers has enabled the beach to attain and the waves to wash the foot of the cliff, thus accelerating their downfall. It is also probable that the removal of the boulders and larger pieces of shale washed out of the cliff *detritus*, for building and other purposes, has exerted its influence in assisting the encroachments of the breaking waves of the lake. Sketch No. 7 may afford an illustration of the appearance and power of these breakers as they dash at an acute angle on the beach during the continuance of easterly and south-easterly winds.

A question of much interest and importance suggests itself with respect to the first or lower terrace. It may be urged that a plateau of the altitude of 160 feet, extending in gradual surface lines in the form of a promontory, would be a sufficient

source of materials and afford the necessary topographical conditions to produce modifications of Mr. Fleming's hypothetical early development of Toronto Harbour as shown by his diagrams No. 9, 10, 11, 12 and 13, and thus in part give countenance to his view of its remote history. Mr. Fleming says, "On the subsidence of Lake Ontario from a high to its present level, the land fell in easy slopes to the water's edge, and the gradual descending surface lines were continued outward under water; the abrupt terminations of the land along the boundary of the lake having been formed by its enroachment through a long course of ages, the promontories which formerly projected have been rounded off by the destructive influence of the elements."

That an arm of the sea did occupy the region of Lake Ontario and Lake Champlain during the tertiary epoch there is little reason to doubt. The occurrence of marine shells and skeletons of marine fish (Mallotus Villosus) 540 feet above the sea or 310 feet above Lake Ontario, at Montreal, in the Valley of the Ottawa near Bytown, in the Valley of Lake Champlain, and in many localities in the Valley of the St. Lawrence, afford ample proof of this vast phenomenon. (Lyell's first voyage to the U. S p. 119, vol. 2., New York edition. See also Provincial Geological Reports, Ottawa Valley.) It has, however, been shown that the phenomena of the highest terrace can have nothing to do with the formation of Toronto Harbour, seeing that it has only been attacked to a trifling extent and probably within the last fifty years. It becomes necessary, therefore, to advert to the period when Lake Ontario, probably as an arm of the sea, or a fresh water estuary, stood at an altitude of 160 feet above its present level, or in other words washed the base of the second or highest terrace. There is every probability that this event extended over a long period of time.

Ridges corresponding to the plateau of the lowest terrace have been described by Mr. Hall in the geology of the fourth district of New York: "One of the most interesting of the superficial deposits of the district is the lake ridge, which, from Sodus, in Wayne County, with some trifling exceptions is a travelled highway nearly as far as the Niagara River. Beyond this it can be traced quite to the head of Lake Ontario, and I have been informed that it exists upon the northern side of the lake." In a note attached to the remarks of Mr. Hall on the lake ridges, we find the following: "To the geological reader it will require no attempt to prove this the ancient beach of Lake Ontario, or a body of water, perhaps an arm of the ocean, which once stood at this elevation; such occurrences are well known elsewhere; but there are many persons in western New York, and some grave critics among the number, who prefer to explain this by supposing some stupendous uplifting of the strata in this line from Sodus Bay to Niagara River." Further on (p. 351) Mr Hall states that "the elevation of this ridge above Lake Ontario has been variously estimated from one hundred to two hundred feet. In 1838, through the kindness of Mr. Barrett, I obtained the elevation of the ridge north of Lockport, which is about *one hundred and sixty feet* above Lake Ontario."

It is probable that the formation of the New York ridge above described was contemporaneous with the lowest terrace of the Scarborough Heights, and may not the persistent layers of water worn pebbles described before as being about ten feet below the surface of the plateau be the ancient beach of Lake Ontario at its former altitude? It is reasonable to suppose that when, by a slow upheaval of the country, the level of Lake Ontario became comparatively lower and lower, the strata of alternating sand and gravel and blue clay forming so large a portion of the cliffs of the lowest terrace would have remained persistent and permitted the land to fall in easy slopes to the present level? Is it not rather to be supposed that its shores would have been terraced and abrupt like those descents which are to be seen about four miles from Toronto, where the lowest terrace leaving the lake crosses the road from Toronto to Kingston? If this were the case, and there does not appear to be any reasonable objection to the hypothesis, the lowest terrace instead of descending in easy slopes when the land became elevated would form at least two distinct terraces abruptly bounded by declivities of sand, precisely like the abrupt declivities seen on the Kingston Road, near the eastern extremity of Ashbridge's Bay, which are nothing *more or less* than the abrupt *sandy shores* of the ancient lake as the land slowly rose from beneath the bed of a tertiary estuary or ocean.

Under such circumstances the existence of any promontory becomes very doubtful, and the coast line would appear to assume an extension commensurate with the former

extension of the whole northern coast of Lake Ontario, which, in its earlier development extended probably nearly uniformly a short distance lakewards. The protection afforded by lake beaches, during periods of low water, is so great that it may truly be said that the cliffs or bluffs of the coast are only submitted to the denuding action of atmospheric forces during those epochs, an action which tends to give them the form and conditions essential to the growth of vegetation, which, in not a few instances, extends without the occurrence of cliffs or even of quaternary formations to the very shores of the lake.

Other objections might be advanced against the existence of a promontory or even a considerable extension of the coast of the Scarborough Heights lakewards since their emergence. Such, for example, as the great depth of water which exists in the lake to the south of the Scarborough Heights.

Lieutenant Herbert clearly shows soundings of 48 feet *within* a mile of the coast, and in one locality, west of the Highland Creek, the great depth of 120 feet is recorded *within* two miles of the coast; what denuding operations can have produced these great depths since the assumption of the present level of Lake Ontario, if the land extended lakewards to a considerable distance, even half of the distance assigned by Mr. Fleming (about two miles—see section and scale) during that epoch? The occurrence, it is said, of tertiary blue clay within two or three hundred yards south of Ashbridge's Bay is another objection which, combined with the known dip of the Silurian rocks in that locality, suggests grave doubts as to the former extension of the land to a degree consistent with the idea of a promontory.*

Mr. Fleming's views of the origin of the delta of the Don are also scarcely consistent with the probable topographical condition of the country when the lake assumed its present level. The supposition is not admissible that the country rose from beneath a tertiary ocean (see Geological Reports for 1845-46), in a sudden and violent manner. It occupied, most probably, a vast epoch of time; if it emerged at twice the rate at which Sweden is now becoming elevated, namely, at the rate of five feet in a century near the North Cape, and a few inches in a century near Stockholm, (see Lyell's Second Voyage to the United States, Vol. 11, p. 194, New York edition) it would have required 32 centuries for the hills in Scarborough Township to have emerged; or if we take the lower, and, perhaps, best defined sea beach, the one of the lowest plateau, 160 feet above the present lake level, it would still have embraced 16 centuries, and this too upon the supposition that the rise was continuous, which is known not to have been the case, as lower beaches testify. During that period, how would rains, snows, and dews drain away from a country "totally devoid of water channels for surface drainage," as Mr. Fleming supposes when he assumes that the Don *began* to exist when the lake had acquired its present level. The Don, together with all the rivers and streams of any magnitude which now flow into Lake Ontario, *began their existence with* the uprising land and grew with its growth, excavating the valleys through which they now flow to within a few feet of their present level, during the successive epochs of the subsidence of the lake had from its former vast extension. The *detritus* of the Don and other streams brought down during higher lake levels, forming sand bars and mud flats, are now pine clad ridges and the cleared farms of thriving settlers. On the south shore of Lake Ontario the valleys of streams which fell into the lake when it stood at an elevation of 160 feet higher than at present are plainly visible. Mr. Hall says, "the interruptions in the continuity of the ridge from the passage of small streams are numerous throughout its whole extent. Many of these streams were doubtless discharging their waters into the lake at the time of the formation of the ridge, and have thus kept an open passage, others have been closed up during its deposition, and formed little ponds upon the inland side, which, subsequently becoming more powerful, have burst through the barrier and carried away large portions of it." (Geology of the 4th District, p. 350).

It is suggested that the term "delta," is altogether a misnomer, leading to the idea that the River Don has brought down materials from its excavated valley and deposited them at its mouth, and elevated them above the surrounding waters, like the Nile and the Mississippi, only on an infinitely smaller scale.

Now the banks of the Don at its mouth are of tertiary yellow and blue clay, and there was a time, no doubt not very far removed from us now, when those banks were

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* See App. Note "E."

washed directly by the surges of Lake Ontario. It is abundantly evident that the Don, within the limits of the Christian era, poured its waters directly into the lake, as the absence of *made land*, which alone constitutes a delta, well proves, without reference to the deep waters of the marsh, and the absence of that evidence of antiquity which one would expect to find if the Don had for many ages contributed its *detritus* to fill the space intervening between its mouth and the opposite, though somewhat far removed shore of the lake boundary of the marsh.

It is, however, important to inquire what phenomena exhibit themselves at the mouths of rivers pouring their waters directly into the lake, such rivers, for instance, as the Rouge, the Humber, the Mimico, and the Highland Creek, which are severally larger and smaller than the Don, and consequently comprehend either extreme in point of dimensions. It is important to know whether it is probable, or even, under ordinary circumstances of wind and weather, possible for the Don to have formed a *bar* (the proper term) as far from its mouth as the south sand beach of Ashbridge's Bay.

The testimony of Mr. Hall is peculiarly appropriate in the present instance. Speaking of bars at the mouths of rivers and streams, he says: "The bar is formed by the influence of two forces—the waves washing in, which carry forward the sand and deposit it in long beaches; and the opposing power of the steady current, which neutralizes that of the waves, and the sand then falls down in a broad curve. The force of the current is principally expended in opposing the waves of the lake, and becoming diffused it flows quietly over the bar. This continues while there is no more than ordinary force in the waves, but on the occurrence of a violent north-east storm (*i.e.*, near Genesee) the whole of this bar and perhaps ten times as great an amount of matter is thrown upon the beach, closing the outlet. This remains so long as the wind continues, but as soon as it subsides and the water in the pond is able to force a passage through the beach, the old order of things is resumed, to be again subverted and again renewed. Such simply, is the operation of one stream, as it has existed for the last four or five years, and such would be the history of hundreds of large and small streams along the lake shore." (Geo. of 4th Dist., p. 356.)

The knowledge acquired by the inspection of any stream pouring its waters directly into Lake Ontario shows that it is impossible for a small river like the Don, even if it were ten times as large, to form a bar a mile from its mouth, and water of 18 to 20 feet in depth to intervene. Nor is there any reason to suppose that the Don was ever a stream much larger than it is at present. Those who are familiar with the cutting action of rivers, first attacking one bank, then, by landslips or fallen trees, driven to the opposite bank, will feel fully satisfied that the Don in its present development is abundantly sufficient to explain the denuding action it has exercised since it began to flow with the slowly receding waters of a tertiary ocean.

We may, however, gain some clue as to the age of the marshes of the Don, and the beaches which confine them, by examining other marshes and beaches which have been long under examination. In geological investigation everything is to be learnt by *comparison*, and he who speculates upon an incident without taking cognizance of similar occurrences must expect to be called upon to furnish a separate theory for every phenomenon differing in externals from the class to which it belongs.

In describing the ponds, marshes and beaches which lie to the west of the Genesee River, Mr. Hall mentions a few facts which will enable us to form some idea of the probable age of the "delta" of the Don.

"The beach before alluded to, between the lake and these ponds, is nearly a mile long (near Genesee; see Lt. Herbert's chart), before coming to the outlet, from fifty to one hundred feet wide, and, generally, not more than five or six feet above the lake. *For the last few years** it has been wearing away (1842), and the roots of large trees growing upon it are becoming exposed, and some of the trees themselves are thrown down."

"Further westward the space between the lake and the marsh is five or six hundred feet wide. This is occupied by three distinct ridges, running parallel with each other and with the lake. Near the western extremity these three ridges divide into four, but continue equally well marked. Their summits are from six to ten feet above the lake, and

*High water of 1838 equal to that of 1853.

the valleys between them are from four to six feet below the tops of the ridges. The materials of which they are composed are similar to the recent lake beaches, consisting of pebbles and sand covered with a light sandy loam. They are overgrown with large trees of oak, elm, beech and buttonwood, which shows their antiquity. Their form is distinct and well marked, while the cause which gave rise to them *more than a hundred years since* is still active, producing other similar ones before our eyes."

Mr. Hall is contented to limit the duration of the existence of lake beaches separating marshes from the lake, and containing far stronger evidences of *antiquity* in the form of large trees of "oak, elm, beech, and buttonwood" than any portion of Toronto Harbour leaches, to a period of "more than a hundred years."

Further on he says: "I might go on to illustrate the condition of the beaches and outlets further to the west, but these few examples are applicable to the whole. The ridge of beach west of Long Pond is undivided, and in many places from ten to twenty feet high, showing that a variation of a few feet in height can be no objection to the mode of formation."

"For many years previous to 1835 the lakes were all at a lower elevation, and *this allowed the formation of bars and beaches* at the outlet of streams which before opened by a deep channel into the lake." Mr. Hall here hints at a condition of things which will be shown hereafter to have exercised a remarkable influence upon the conformation and stability of the marshes of the Don and Toronto Harbour.

One more example will suffice to illustrate the comparatively modern formation of beaches and marshes on the shores of Lake Ontario. "Some of the bays along Lake Ontario formerly admitted vessels for several miles, while at the present time they are partially or entirely closed. The beach formed at the mouth of the Irondequoit Bay has a narrow opening of three feet deep, while formerly it was a quarter of a mile further east, and of a depth sufficient to admit sloops which took in freights at the head of the bay *three miles* distant. The bay is so situated that it receives the abraded materials of the banks of the lake, both from the east and west. It is one mile and a quarter wide, gradually narrowing southward; and is separated from the lake by a sand bar or beach from fifty to two hundred feet wide, and rising from three to twenty feet high. The *greater part* of the beach has accumulated within the last *fifty* years. At that distance of time it was very low, and scarcely covered with grass; it is now overgrown in some places with large trees. The sand and silt brought down by the streams into this bay are gradually filling it up, and eventually it will become a marsh, with the stream winding through it to the lake."

From these quotations it is evident that extensive formations, such as beaches from four to twenty feet high, swamps with vast accumulations of vegetable growth far exceeding the Don marshes, have sprung into existence during the last few centuries, adopting a wider margin than Mr. Hall, who merely says, "more than 100 years ago." Now, in the absence of any evidence of greater antiquity than that which may be embraced within a period of a few centuries, it does not appear reasonable to *assume* such antiquity when every existing phenomena may be accounted by comparison with surrounding and nearly contemporaneous events. It is again urged that the great depth of water (12, 16, and even 18 feet) between the marsh *boundary* and the mouth of the Don, together with the great distance by which they are separated, are geologically quite sufficient to exclude the idea that any connection whatever has existed between the formation of the one and the *detritus* of the other. The peninsula beach would have existed in nearly its present form and extent, if the Don had never begun to flow. A perfect type of the peninsula, only of larger extent and more complete growth, is found at the Rondeau, Lake Erie. It embraces an area of 6,000 acres of water. The shallowness of Lake Erie readily explains the giant size of this and other similar formations in that lake; the long swells and tempestuous waves which distinguish that easily agitated lake are due to its small depth.

It now remains for the writer to explain the views he entertains of the formation of Toronto Harbour, and then proceed to the discussion of those remedial measures which the conditions of the case appear to require. These views are not submitted without due acknowledgement of the great interest which distinguishes the theories of Mr. Fleming and other gentlemen who have recorded their opinions; and the writer would never have publicly appeared in this controversy if he had not thought it the bounden duty of everyone

whose thoughts had been turned to the subject, to discuss, to the best of his ability, a question involving the very existence of the City of Toronto as a commercial emporium.

The subject of *travelling beaches* is one which has long engaged the attention of geologists, and is in the present instance of peculiar interest. Sir Henry de la Beche, in the *Geological Observer*, points to the action of the sea on coasts in the driving forward of shingle, in a particular direction, by breakers produced by the action of prevalent winds, under the influence of headlands. (*Geological Observer*, Philadelphia edition, 1851, page 83). The illustrations given by that eminent geologist are perfectly applicable to the great North American lakes, due allowances being made for the height and length, and, consequently, the force of the waves, as well as for the difference in the specific gravity of fresh and salt water.

Mr. Fleming has correctly described the *effect* produced upon the Scarborough beach, as regards its westerly motion, under the influence of winds impelling waves or undulations over the greatest expanse of the lake. It is believed, however, that a few points of material importance may be added by way of illustrating the action of waves on the coast, and the subsequent distribution of the beach they transport. Any wave raised by winds blowing in a direction east of a perpendicular drawn to the general direction of the coast (see Mr. Fleming's Chart, also Chart No. 8,) will begin to curve inwards the moment the wave becomes retarded by the increasing shallowness of the water. The time when this influence on the direction of the wave begins to be appreciable is entirely dependent upon the height of the wave; for it has been ascertained that a wave *begins to break* when it reaches water of a depth *equal to its own height.* (See Reports of the British Association for 1837—Report on Waves.) Its influence upon the bottom is exerted before it attains a depth of water equal to its own height, and the retarding effect of a shoaling coast is felt at some considerable distance from the shore—dependent, of course, upon the depth of water. These effects give to all waves the curved forms shown in figure 8. But there is another and a far more powerful influence which gives a curved form to waves as they approach the coast (Scarborough) when the wind is blowing in an easterly direction, or to the north of east: the influence of *protecting headlands.* The shallowness of the water induces the waves to break when they approach the shore, which they do in the form of a curve, but the influence of a protecting headland is felt long before the wave reaches shallow water on a shoaling coast like that of Scarborough. The influence of a protecting headland is extended to waves in water of any depth. By reference to the Chart No. 8, several systems of waves will be seen, some merely curving inwards by their approach to a shoaling coast, others (A, B, C, D, E, F,) curving to a much greater extent under the influence of the protecting headland shown on the chart. The same argument applies, though in a far less degree, to the waves (P, Q, R, S) which, although coming from the east, will have a *tendency* to move the sand of the west shore of the peninsula *northwards*, where one would suppose it to be entirely safe from the effects of easterly waves. Sir Henry de la Beche is very precise on this subject. He says, "the lines of waves are shown by dotted lines made to curve inwards by protecting headlands." (Geo. Ob., p. 84). It is urged by the writer that waves driven by belts of winds acting in the direction and position of the arrows 1, 2, 3, 4 (Chart 8) would be obstructed by the headland at Y, which, when clothed with pine forests, was far more influential than it now is, although now it affords protection to small craft anchoring outside Ashbridge's Bay from all winds to the *north of east.* It is well known that the influence of headlands is manifested every where on the sea coast, and often gives to certain harbours their value against the destructive effect of particular winds. It appears manifest that a travelling beach from K to Y would be arrested after it had passed Y, and begin to be deposited at O, O, O (see Note "C" Appendix; remnant of an ancient beach.) Belts of wind 1, 2, 3, 4, could have no effect upon the beach at O, O, O, O, nor would belts 5 and 6, as they would act under the lee of the land. The argument applies *a fortiori* to ALL winds blowing from the *north of east.*

The origin and formation of the peninsula appears to the writer to have been as follows: At a period far within the limits of the Christian era, the coast line of the Townships of Scarborough and York was continued without interruption round the north shores of Ashbridge's Bay and Toronto Harbour. The Don flowed then directly into the Lake, like the Humber, Mimico, etc., at the present time, without depositing any more

"delta" or bar than other rivers of its class are observed to do, and exercising no influence whatever upon the formation of any portion of the sand beaches and shoals under consideration. Sand bars would frequently be formed under the influence of the protecting headland, about four miles from Toronto, and as frequently be washed away by storms during periods of high water, their materials being distributed far and wide. With these sand bars pebbles and shingle would be occasionally mingled, and time after time might be deposited, from their great specific gravity, to form a basis for a permanent sand bar. A period of high water arrives, like the one just terminating, like the period of 1838, or of 1788, and during that period a sand bar of larger growth was deposited under the protecting headland—a period of low water follows, like that of 1819 or that of 1848, and during that period the sand shoal was washed up into a sand beach similar to the sand beaches before alluded to, as described by Mr. Hall, near the mouth of the Genesee (see Herbert's Chart), and of which thousands of their kindred are to be traced on the shores of all the great lakes, formed under similar circumstances, "more than a hundred years ago."

This beach would undergo numerous modifications according to the height of water, which fluctuates in Lake Ontario to the extent of five feet (some authorities say eight feet), but as soon as its western extremity had progressed beyond the influence of the protecting headland, it would be swept round to the north shore, forming the spit from the peninsula beach to near the windmill. Now, all this might have occurred during one period of low water (a few years), or it might have occupied several periods. It is, however, probable that the beach surrounding Ashbridge's Bay and the marsh was thrown up and round during one period of low water in the lake. Now begins the existence of the marsh, which is described as consisting mainly of a floating bog, but which has been making rapid progress of late years, as a few illustrations will prove. About 250 or 300 yards south of the bridge over the Don now being built by the Grand Trunk Railway Company, an old brickyard is seen (April, 1854). The clay has been dug out to a depth below the present level of the Don, and the hollows are occupied with reeds, rushes, and swamp plants. A farmer who has resided near Ashbridge's Bay, not two miles from the City Hall (next to Leslie's), stated to the writer that he considered he had lost about five acres during the last thirteen years by the encroachment of the marsh, but he expected he should regain some of it *when the waters fell.* The remains of a fence at least 60 yards distant from the present boundaries of the rushes is distinctly visible in one portion of the marsh. These encroachments have been made during periods of high and low water, and arise from the invasion of the land by the rushes and other swamp plants. They are merely presented as modern instances of rapid encroachment, but without relation to the main question.

Chart No. 6 represents a plan of the peninsula. The dotted lines indicate the longitudinal axes of the beaches which were thrown up one after the other during the progress of the formation. The dotted line No. 19 represents the bar now in the act of being thrown up into a beach by the lowering of the waters of the lakes, which are now (April 20th), *two feet lower* than in *June last.*

The materials of which the beaches are composed have travelled along the beach of Ashbridge's Bay, impelled by winds and waves before alluded to. The materials originated in the continued destruction of the Scarborough Cliffs. *This portion of the theory of Toronto Harbour is entirely due to Mr. Fleming, to whom the credit of having first given it to the public is unquestionably due.*

It is with some degree of confidence suggested that the several beaches denoted by the dotted curved lines on Chart No. 6 represent the successive epochs of additions to the peninsula, and that they are the visible and permanent records of the periods of low and high water which have distinguished the recent history of Lake Ontario. Five beaches are distinctly seen between the lighthouse and the utmost south-westerly extension of the peninsula.* These may correspond to such periods of high and low water as are known to have occurred in 1788, 1838 and 1853, and in 1819 and 1848, and probably in 1854 or 1855. The question is one of much interest and deserves further investigation.

The history and mode of formation of the peninsula having been pointed out, it is now proposed to discuss the question whether a permanent opening at the end of the bay

* See note "C" in appendix.

would be a benefit, and first of all whether such an opening in the form of a canal could be maintained at a reasonable expenditure.

It is manifest that in order to make such an opening permanent, which is evidently the first point to be considered; sand and shingle must be prevented from "travelling" into it from the east, which would without doubt be the case if no preventive measures were adopted. We are not, however, permitted to assume that an opening in any one part of the peninsula would suspend the operation of those forces which have given a local habitation to the whole beach from Ashbridge's Bay to Gibraltar Point. Assuming that an opening were made, say near the Peninsula Hotel, and that by groynes or other devices sand and shingle were prevented from closing it, it is perfectly clear that in order to effect this result the first object would be to retain the sand and shingle *east* of the opening. Suppose this to be accomplished, what, it is asked, would become of the remaining western portion of the peninsula? Would the sand and shingle there cease to be a travelling beach? Would it cease to move westward as heretofore? There can be no doubt that if left unchecked it would progress onward, being still subject to the same controlling forces as before. But if it progressed, the beaches to the west of the opening would be rapidly moved away and form an extensive natural breach, seeing that no advance of materials to *supply their place* could take place, they being preserved to the eastward of the opening for the sake of maintaining it. The peninsula, under such circumstances, would rapidly become an island, and its extremity near the canal gradually assume the form of the western extremity throwing out tongues and spits in a northerly direction. But it may be urged that the sand might be prevented from "travelling" by means of groynes. It is true the construction of groynes from the canal all the way to Lighthouse Point, at short distances apart, would have that effect for a time, but without they were made very high the sand would mount over them and form dunes, according to laws painfully recognizable in many parts of Europe, and especially in the "Landes" of France, as well as on the shores of Lake Huron. (See Sir H. de la Beche on this subject, Geo. Ob. p. 84.) Again, the groynes would have to penetrate into deep water beyond the influence of waves upon a shoaling coast, or how would they check the progress of the shelving beach which is disturbed by the long waves of an easterly gale to a greater depth than fifteen feet?

The peninsula, in its sub-aqueous extension, is an enormous sand and shingle shoal, very shelving on the lake side, and, where it has not been remodelled or disturbed, very precipitous on the bay side.* The testimony of the fishermen of the present day in relation to it is the same as when Sir Richard Bonnycastle wrote: it consists, lakewards, of immense fluctuating shoals. These shoals extend lakewards 1,500 yards before they attain a depth of 30 feet, except in one spot, and that is near the Lighthouse or Turning Point. Bay-wards the shoals are in general precipitous, and the openings which have, from time to time, been made in Ashbridge's Bay and the peninsula have scarcely changed the precipitous character of the bay sides. They have merely succeeded in shifting the boundary a little northwards, but they have not materially changed the form of the coast or its sub-aqueous extension in either bay. The writer took pains to examine the effect of the waves breaking over about one-third of a mile of the coast of Ashbridge's Bay this season (April, 1854), and found along the bay side of the beach 6, 6½ and 7 feet of water *within* 15 or 20 feet of the bar, over which the waves broke furiously, and had been breaking for weeks, under the influence of the easterly gales which have distinguished the present spring (See Note B, in Appendix). It is well known that the late breach near the peninsular hotel is wholly filled up, and that its effect upon the bay has been comparatively insignificant.

It will be seen that the arguments against the construction of a permanent opening apply with greater or less force to every portion of the beach from its eastern to its western extremity. A canal from Ashbridge's Bay into the lake would, *a fortiori*, be still more objectionable than one near the Peninsula Hotel, as it would involve the strengthening of the whole of the beach as far as the Lighthouse Point to prevent its westward motion. The next question which suggests itself, *assuming* the preservation of the beach provided for, is the possibility of keeping an artificial canal open anywhere between a few hun-

*See Note H, in Appendix.

dred yards east of the point and the most remote extremity of Ashbridge's Bay, without continued and expensive dredging. When we remember that many million tons of sand and shingle have passed over the beach from Scarborough shore to form in 58 years the 30 acres in deep water beyond the Lighthouse Point, when we glance at the new beach which has recently been thrown up west of the point, when we consider the changed character of the Scarborough cliffs, unprotected as they now are, is it probable that a canal could be maintained within the limits before mentioned? Is it not rather to be supposed that the sand would accumulate on its eastern side with a rapidity before unknown, and defy the most energetic efforts to preserve a passage during the winter season? The rapidity with which natural breaks fill up, as shown repeatedly in Ashbridge's Bay, and recently near the Peninsula Hotel, furnishes also a safe answer in the negative to this question.

It appears manifest that the integrity of the peninsula must be preserved; that no artificial lake communication, situated between the Lighthouse Point and the eastern extremity of Ashbridge's Bay, could be maintained under the existing conditions of the Scarborough Cliffs, without an enormons outlay at the commencement, and an annually increasing expense in maintaining it.

It is urged that the chief objection to the construction of groynes into only eight or ten feet of water is the nature of the sloping beach, the fluctating shoals, which in places are not twenty feet below the surface of the water, seven hundred yards distant from the shore. Mr. Fleming's own measurements, opposite his proposed canal, give a distance of nearly 700 yards before the shoaling coast reaches a depth of twenty feet of water. The whole question of the construction of groynes is involved in a distinct and exact knowledge of the depth to which the surges of the lake affect the sand and shingle of the shoal. It is manifest that if a groyne were not constructed into water deeper than that in which the waves have the power to move the sand at the bottom, it would be of little avail. Let us suppose, for instance, that groynes were constructed on the sand bars to the depth of twelve feet of water, and that the high waves of the lake affect the bottom to a depth of fifteen feet. *

The sand during storms, namely, those which produce the longest and highest waves (the easterly storms), would be disturbed to the depth of fifteen feet and pushed round the projecting groyne, other sand from above or the east, falling down by gravity or pushed along by the impelling waves, would fill the place of that which had been removed, and be in turn swept westward, and so on repeatedly. A really useful groyne must penetrate into water of a depth *beyond* the ordinary influence of the waves upon the shelving bottom during storms, which certainly extends on the peninsula shoals to a depth exceeding fifteen feet. There is a spot on the peninsula where a groyne can be constructed to serve every purpose required. Mr. Fleming has justly recommended a groyne at the Lighthouse Point (the south-western point of the peninsula), and it appears to the writer that *that* spot is the first which should be selected for the construction of a groyne. But Mr. Fleming's suggestion that the groyne should be carried out into eight or ten feet water is altogether incompatible with the effect produced on the sand at the bottom below that depth by the long swell of the waves.

The writer, while duly acknowledging Mr. Fleming's appropriate selection (as it appears to him) of the locality, would suggest that one groyne should be carried out there into 40 feet water. When the peculiarity of the beach and shoal at the Lighthouse Point is considered, the magnitude of the work will not appear to be so imposing as it seems to be at first sight. The boundary of the peninsula at its south-west extremity is extremely abrupt, so much so that at the point A on the chart No. 9, the depth of water is not less than 40 or 50 feet within 400 feet of the beach, (leaving a wide margin for recent changes, possible, but not probable). The soundings on the map are taken from personal observation and Mr. Fleming's chart, and they indicate a steep abrupt boundary at the turning point of the shoal. This peculiarity, in the conformation of the Lighthouse Point in its sub-aqueous extension, will necessarily be maintained for a long period of time, as every successive step in advance is into deeper and deeper water. A few hundred yards to the west of the point, 90 feet water is recorded (Lt. Herbert). All progress of the beach, therefore, in a south-westerly direction must be made by vast accumulations in deep

*Note D, in Appendix.

water. This point serves as a protecting headland round which the travelling beach is rapidly moved by easterly winds, and as rapidly forwarded northward by south and south-westerly winds.

A groyne at A, bisecting the segment of curvature would, if run out into 40 feet water, arrest all sand and shingle for a considerable period of time, and, as the accumulating materials encroached upon the protecting limits of the groyne, further increase could be arrested and the materials *fixed* by placing a second groyne at B; in process of time the travelling beach would encroach upon the protecting limits of B, a third groyne placed at C, on a smaller scale, would arrest further progress and *fix* the sand between C and B; a fourth, after a few years, would be required at D, and so on, as materials accumulated. The results of this system would be the establishment of the peninsula upon a firm basis, adding year by year a large quantity of what might become valuable property, if properly taken care of and embellished with, as well as sustained by, appropriate trees. The western extremity of the peninsula is also subject to the inroads of travelling beaches, as not only its formation, but the extension of the sand bar sufficiently shows, and has shown for many years. (See Gzowski's report, noticed before.) A groyne at E would, if made to penetrate to 15 feet water, effectually retain the moving beach, and preserve the integrity of the distance between A and E, and, finally a groyne at FK, as mentioned by Mr. Fleming, would establish the channel, and, if curved sufficiently far in the direction of K, a permanent beach would be thrown up during the next period of low water, which would secure a current in one channel of at least 12 feet of water, sufficient to preserve it from possible inroads of sand, which might be deposited in the form of bars *within it* during summer currents, to be hereafter noticed.

In the meanwhile, what, it will be asked, is to become of the more easterly portions of the peninsula? Is there no danger of any part of that narrow strip between the Peninsula Hotel and the extremity of Ashbridge's Bay being swept away? Nature herself supplies an answer to this question which, when duly considered, may be correctly interpreted. Nature has made and repaired one breach, during the past year at the eastern extremity of Toronto Harbour; she has made and is now repairing at the rate of an acre a week another breach in Ashbridge's Bay, of a third of a mile long. There is not a doubt that during the whole epoch of the existence of Toronto Harbour, from its first washed up beach to its present imposing magnitude, breaches have been made during all periods of high water, and repaired during periods of low water. The writer is of opinion that several remains of breaches can be recognized in various parts of the coast between the hotel and the eastern extremity of Ashbridge's Bay. These remains distinguish themselves by two projecting spits precisely like those which are now seen where the recently closed breaks existed at the east end of the harbour. Four years ago—during the period of low water in 1849—several of these remains of breaches could be distinctly seen, bordering the swamps and east of it. It is desirable that breaches should not be made, as by slow degrees they limit the dimensions of the harbour, but under certain circumstances, they are of immense importance, as will be shown hereafter. The writer submits, with respect, that no works whatever are required to preserve any portion of the beach from destruction. It will be asked, why not? and it will be urged that the diminution of the beach near Privat's Hotel and elsewhere, in an easterly direction, to less that one-half its width in about two or three years, is cause for serious doubt as to its stability. The writer would beg to call attention to the circumstances under which the beaches became diminished: their diminution is only *apparent*, and where real (if anywhere) it will be rapidly repaired; the beaches expose less surface in consequence of the *unusually high water of the lake.* The average annual fluctuations of Lake Ontario are about two feet, but the difference between the levels of the lake in October, 1849, and in June, 1853, was four feet, five inches. (See Canadian Journal, vol. 2, p. 27.) Now it is suggested that these great differences in lake levels are of the utmost importance, not only with respect to the general appearance of the peninsula, but with regard to its sub-aqueous development. An observer in 1849 would see a broad beach at the Peninsula Hotel, some fifty or sixty yards broader than an observer in 1853, solely on account of the difference in the lake levels, without the necessity of one particle of sand being removed. An observer in 1853 would say the beach is but two feet three inches above the waters of the lake, while an observer in 1849 would say it was six feet eight inches

above the same level, and yet the real altitude of the beach might be precisely the same. So with respect to soundings. The bar which in 1853 had four feet of water on it would be two inches above the water in October, 1849. These are important items ; they show the absolute necessity of exact scrutiny into all measurements relating to the harbour, and the reduction to the same standard of lake level of all observations before a fair conclusion can be arrived at. The influence of difference in lake levels, in other words, of periods of high and low water upon the peninsula is all powerful. This difference has enabled sand bars to be thrown up into sand beaches, and has, in a word, been the great *formative* cause of the whole peninsula. It is beautifully shown even in this tempestuous weather (April, 1854) ; at Lighthouse Point the writer noticed in October last the slow deposition of the spit now protruding itself above water at the western extremity of the point. The Lake was then 3 feet 3 inches above its lowest level in 1849, and the spit was just covered with water in calm weather, and not to be seen from the shore, but easily discernable from the point.* Now it is decidedly a narrow sand beach, but the lake is about a foot lower than in September last. During the present, or rather coming, summer, as the lake falls, it will be washed up into a stable, prominent beach, sweeping round to the north, and enclosing some additional acres, to mark the present rapid increase of the boundary of Toronto Harbour.

One more aspect under which the fluctuations in the level of the lakes may be viewed is in the relation of those changes to the construction of groynes.

It may be supposed, for instance, that during a high lake level a groyne is constructed into 10 feet water—it is known, however, that the difference between the maximum and minimum levels of Ontario exceed five feet (some authorities say eight feet). It is clear that a groyne penetrating into ten feet water during high lake levels would penetrate only five feet during minimum levels, which would have the effect of neutralizing the purposes for which the groyne was constructed. †

This argument becomes perfectly applicable when we consider the nature of the shoals east of Lighthouse Point. There is an immense distance between the lines of 10 and 15 feet water when reduced to the standard of the lake levels ; this distance exceeds in many instances the total length which would be required for one groyne at Lighthouse Point, penetrating into 40 feet water (between 300 and 400 feet) thus involving for the construction of effectual groynes east of Lighthouse Point, where the water shallows, an outlay which, if judiciously incurred, would serve to arrest permanently the progress of the sand, give stability to the peninsula and distribute the expense of future works over a great number of years. It will, doubtless, be becoming in the writer to express more fully the reason he entertains for the opinion that it is unnecessary to protect the weaker portions of the peninsula :—

1. Vast bodies of water in the form of waves may break upon it, and over it, without carrying any considerable quantity of materials into the bay, as before noticed. This arises from the very *gradual sloping* conformation of the shoal lakewards. They may carry the crests during high water, but they rapidly repair the breach. The sloping character of the shoals being always maintained by the mode of their formation, and the waves always *breaking* when they reach water equal to their own *height*, their force is destroyed before they reach the shore. During low water levels, the waves break nearer the shore, the re-arranged materials of the beach are then more precipitous, but during this period the breaking waves exert no force on the crests of the beach, because the emerged land due to the falling of the lake, *protects itself.*

2. It is submitted that we have *passed* the maximum of high water, but, if not, it will occur in June, and before works (supposing they were necessary) could be constructed to protect the weak portions of the beach. It appears quite probable that all period of danger from high water is passed, if we may permit ourselves to be guided by the experience of the past. Mr. Hall, in quoting Mr. Higgins, the Topographer to the Geological Survey of Michigan, embodies in a single sentence the probable state of the case. "He considers it probable that the minimum period continues for a considerable period of time, while the maxi-

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* See Note G. Appendix, (referred to before.)
† See Note I.

mum continues only for a single year."* (Geo. 4th Dist.) This summer, doubtless, we shall see the peninsula apparently extending itself in all directions (as it is already doing) by the subsidations of the waters of the lake, and then will begin to appear and to be thrown up into beaches the vast accumulations which have been progressing during the last two years of high water from the unprotected naked gullies of the Scarborough Cliffs.

The answer to the question proposed by the Harbour Commissioners respecting "the effects which have been produced, or are likely to be produced, by the present breach at the eastern extremity of the Bay of Toronto, particularly with reference to the bar at the entrance to the bay," becomes very materially simplified by recent events, the first event being the natural closing of the breach, the second event the occurrence of another breach of far more imposing dimensions in Ashbridge's Bay. Assuming that the breach had not been closed, it is manifest that the question of its influence upon the bar at the mouth of the harbour would involve the action of the *currents* which modify the form of the bar at the mouth. The currents will be noticed hereafter. The question of the breach being *prejudicial* to the harbour is also involved in the general question of the influence of the currents, and the necessity for strengthening that portion of the peninsula where the breach existed has already been discussed. It has also been shown that a permanent opening could not be maintained at that end of the bay without immense outlay, and is, consequently, not to be recommended. The question of the "advisability or otherwise of enlarging the opening between the harbour and Ashbridge's Bay," is subordinate to the general question of the currents, and will be noticed in the sequel. The construction of a permanent opening into the lake from Ashbridge's Bay has been shown to be infinitely more objectionable than the construction of a canal near the late breach east of the Peninsula Hotel, as involving an enormous outlay for the purpose of protecting its mouth, and preventing, by groynes, the beach west of it as far as Lighthouse Point from continuing to "travel" under the influence of the same forces as those which called it into existence.

It is submitted by the writer that it is quite impossible to separate the effect of the breach at the east of Toronto Bay on the bar at the mouth of the harbour, from the simultaneous and posterior effect of the breach in Ashbridge's Bay.

Whatever beneficial or baneful results were produced on the bar by the opening near the Peninsula Hotel, have been entirely obliterated by a power of much greater magnitude acting unceasingly during the last five or six weeks, and there seems to be no reason to doubt but that 99 per cent. of the good effects produced by any openings or breaches in the bar are due to those which have recently occurred in the lake boundary of Ashbridge's Bay. We can only *suppose* the effect produced on the bar by the opening near the Peninsula Hotel; it cannot now be measured. Observations made in the autumn might have recorded its effect, if any were noticeable, but since the breach was made in Ashbridge's Bay those effects have been annihilated, or, at least, so greatly remodelled as no longer to be appreciable. The reasons for this statement are as follows:—

1st. The opening in Ashbridge's Bay, when the writer's attention was first particularly drawn to it at the beginning of April, was a third of a mile long, and the waves swept through it with terrific violence, producing a current so strong in Ashbridge's Bay towards Toronto Harbour that all expectation of distinguishing the effects produced at the bar by the opening near Privat's (then closed) were entirely dispelled. At another time, towards the end of April, when a few days of calm weather permitted a close examination of the breach, it was found that the waves still breaking over it, although there was very little wind, produced a violent current, which drove the boat in which the writer was seated with rapidity towards the swamp. A calculation was then made of the amount of water projected into Ashbridge's Bay by the rolling of the waves over the beach. The distance exceeded 1,600 feet over which the waves broke. The height of each wave was estimated at two feet, the breadth between fifteen and twenty feet. Assuming the length 1,600 feet, the height one foot, the breadth ten feet, a quantity of water exceeding 16,000 cubic feet would be thrown into Ashbridge's Bay by each system of rolling waves.

† See also Note I.

This occurred on an average once in twelve seconds, or five times in a minute, which would give 80,000 cubic feet of water per minute.

If the Don were 100 feet broad, ten feet deep, and moved at the rate of one foot a second at its mouth, it would throw into the bay 60,000 cubic feet per minute; while the breaking waves over the beach at Ashbridge's Bay, would, in a comparative calm, throw 80,000 cubic feet, at the lowest estimate, into the same general receptacle during the same time. This number does not, it may be very reasonably supposed, represent one-fourth part of the mass of water projected into Ashbridge's Bay over the low beach, during the long continued easterly storms which distinguished the month of April. It is therefore urged that any attempt to pronounce an opinion upon the effect produced upon the entrance to the harbour by the late opening near Privat's Hotel, must be entirely theoretical, as it cannot be fairly represented by soundings taken in April of the present year. It is important to ascertain, how this mass of water projected into Toronto Harbour by the Don, and through the breach at Ashbridge's Bay, distributed itself in passing out of the harbour entrance. The temperature of the water determines the solution of this problem. Six or eight trials showed the temperature of the water to vary from 38 to 42 degrees, both in Ashbridge's Bay, the lake, and the harbour. This is within two degrees both above and below the temperature of water at its greatest density (39.6°), consequently, the density of the water may be regarded as uniform, and hence the current would be equally distributed over the bar at the entrance to the harbour, modified by a current produced by the easterly gales noticed hereafter. In summer it is probable that the surplus water would have escaped almost entirely over the bar at the mouth of the harbour, and would have had little effect upon the channel in deep water. The effect of temperature is beautifully shown in the currents which are established during the summer months at the harbour entrance, and requires a detailed notice. The most permanent current in the bay, having an outward direction, is, of course, due to the Don; but the waters of the bay and Don, being shallow, rapidly acquire an elevation of temperature by exposure to the sun's rays; their specific gravity is therefore diminished. The deep waters of the lake do not attain the same elevation of temperature, and are, consequently, heavier than the surface waters of the bay. The warm and light waters of the bay are pushed out over the bar by the colder and heavier waters of the lake, irrespective of the current of the Don. The cold lake water enters at the deepest part of the mouth of the harbour, and during the summer months establishes an inward current often remarked. Two other currents of importance are to be noticed;—1st. An under, outward current, which is occasioned by *westerly* winds impelling the waves of the lake over the bar into the bay; the same influence, however, pressing upon the waters of the lake, raises them at its eastern extremity, and lowers them at its head. In order to establish equilibrium between the level of the waters in the harbour and those in the lake, an outward under current is established, which, in prolonged westerly gales, is very marked. 2nd. An inward under current at the mouth, when easterly winds are blowing, which have the effect of driving the waters *out* of the bay, and at the same time raising the level of the water at the head of the lake; in order to preserve equilibrium, a powerful under inward current is established in the deepest water at the mouth of the harbour.

It is evident that these currents have given to the sand bar now threatening the mouth of the harbour its peculiar conformation, as shown in Mr. Fleming's chart. These *currents cease* to exist during the maintenance of an opening, either in Ashbridge's Bay, or at the east end of the harbour. Their conservative influence in retarding the progress of the shoal northwards, and its invasion of the entrance of the harbour, cannot fail to be noticed; they form another objection against the construction of permanent openings in the localities named. The late Mr. Roy, C.E., who, as before stated, paid much attention to the phenomena of the harbour, well describes the influence of these currents in his paper published in the *Monthly Review*, for June, 1841.

It is sufficiently clear that the currents just described, irregular and accidental as they are, and *deriving their very existence* from the conformation and growth of the harbour, can only be supposed to exercise an influence, (and moderate in its effects) upon the *form* of the sand bar which threatens the mouth of the harbour.

An effect requires a cause: the cause of the currents is the presence and form of the peninsula, without which they would not have existed; the currents are destroyed by

destroying the integrity of the peninsula. It follows, as a matter of course, that the currents could not have produced that which has given birth to them; an hypothesis which, in spite of the contradictions it involves, has yet found supporters.

The writer presumes that the Harbour Commissioners will permit such an interpretation of their words, "Means to be adopted for the improvement and preservation of the harbour," as to allow the introduction into this Report of remedial measures which have not been specially referred to in their published notice.

The suggestions which the writer begs leave to submit are introduced, without present comment, into the following recapitulation of the statements advanced in relation to the history, formation and preservation of the harbour.

1. The harbour, in its utmost extension, is altogether a modern formation.

2. Its formation is due to the present existing *protecting headland* of the west commencement of Scarborough Heights.

3. Its original form was a sand bar, or shoal, deposited under the protecting headland, in a position a little to the south of its present situation. The materials of which the sand shoal was composed were derived from the east, being impelled by easterly winds during a period of high water, and then washed up into a beach during a period of low water.

4. The Don exerted no influence whatever on the original formation or extension of the sand beach, but the beach was extended westerly, under the headland, by the same causes which originated it, until it advanced so far as to be removed from the influence of the protecting headland. Subsequently, it was swept round in a northerly direction, more particularly by south and west winds, until it enclosed the space now occupied by the marshes of the Don and Ashbridge's Bay.

5. The whole valley of the Don was excavated ages before the enclosure took place, and the marshes have been produced by the same vegetable growth which now converts the ponds of the peninsula into reedy swamps. (Witness the ponds south of the lighthouse, during the present generation.) The *detritus* of the Don has accelerated the formation of its marshes, but that *detritus* consists only of the fine mud which can be mechanically suspended in water.

6. The peninsula proper has been formed by "travelling beaches," impelled along the boundary of the present Ashbridge's Bay and its westerly extension. There is every probability for supposing that each successive beach, as shown by the dotted lines on Chart 6 and Sketch 10, are permanent records of *low lake levels*.

7. The boundaries of the peninsula have been immensely extended during the last 58 years, and the addition of so many acres in deep water beyond the lighthouse implies the *sub-aqueous extension* of the shoals forming the sloping lake sides of the peninsula to a very considerable degree southwards.

8. The materials have been obtained by the destruction of the Scarborough Cliffs. (Mr. Fleming.)

9. The operations of settlers, during the last forty years, in clearing the crests of the cliffs in Scarborough have occasioned the immense recent destruction there visible, and have produced, to a great degree, the alarming progress of the peninsula boundary of the harbour.

10. Previously to the settlement of the country the cliffs were much protected from atmospheric influences by trees, underbrush and grass growing on their crests and down their sides, and the beach by natural groynes of fallen timber, also by the large fragments of shale and boulders washed out of the drift, which have been removed for building purposes.

11. The progress of the travelling beaches may be arrested by groynes.—(Mr. Fleming.)

12. The groynes must penetrate into a depth of water beyond the influence of the great waves of the lake upon the bottom, and the maximum and minimum level of the lake must be taken into consideration in ascertaining the depth to which they ought to be constructed.

13. The effect produced upon the beach by waves washing over it, or, in some instances creating openings, is merely to change its position, and move it a few yards to the north; this is a consequence of a vast extension of the sloping beach southwards.

14. There is no danger of a *permanent* breach being made by the waves of the lake.

15. Breaches are due to the concurrence of storms and high lake levels, and no breach would have been made near the Peninsula Hotel during low lake levels.

16. Evidence tends to show that the maximum level of the lake lasts for one or two years only, whereas the minimum lasts for several years. The maximum level of Lake Ontario, for the present period, was attained, very probably, in June last, when the level was 4 ft. 5 in. above the level recorded by Captain Lefroy, in October of 1849, at the Queen's Wharf. There is a remote probability of the level this year being equal to what it was last year, owing to the late severe winter. This is a point which will soon be ascertained. The level (end of April, 1854) is now 2 ft. 1 in. lower than in June last.

17. In order to preserve the harbour from closing, a groyne must be constructed at Lighthouse Point into 40 ft. water, which will cause the sand to 'back up' against it, and extend the dimensions of the shoal southwards; in a few years a second groyne must be constructed at B on the map, and, after another interval of time, a third groyne at C, then at D, (each groyne being smaller than the preceding one), and so on. The effect of this system of groynes will be to extend the shoal southwards into deeper and deeper water, and gradually 'back up' the progressing materials *to their source*, thus immensely strengthening the peninsula, and making it a permanent and stable tongue of land. The sand may be prevented from forming dunes by planting trees, beginning with the formation of new land, and planting as the *land forms*. (If groynes were to be constructed first, say at the hotel, and then westward, it would be necessary to plant the whole coast at once, which would be a difficult matter.)

18. Simultaneously with the construction of a groyne at A, a groyne into 15 feet water must be constructed at E M, and simultaneously with this a groyne at K F. (Mr. Fleming.)

19. It is most desirable to produce a current between the Queen's Wharf and the groyne. In order to effect this object the Don must still be permitted to enter the Bay, but not by its present mouths. They should be closed, and a mouth opened at H, and a channel cut for the Don south-east of the railway bridge. Two or more channels would be better, for the purpose of preventing the cutting of a deep passage by the waters of the Don; the channel might be conveyed to different parts of the marsh. The progress of consolidating the marsh by this means would be very rapid. The waters of the Don would then percolate through the marsh, and if they cut a deep channel they would have time to deposit much of the mechanically suspended matter with which they are charged during freshets, and, if they did not cut a new deep channel, the reeds would act as filters, like the reeds in the swamps bordering the Mississippi (see Lyell, 2nd Voyage to America), and effectually arrest all silt. The sewage of the town should be made to flow into the Don; in the marsh it would become inoffensive, being rapidly consumed by vegetation. The waters of the bay would thus be greatly purified. The passage of the Don through Ashbridge's Bay *could not be maintained.*

20. Any permanent opening in the form of a canal between a few hundred yards to the east of Lighthouse Point and the eastern extremity of Ashbridge's Bay could not be kept open without the construction of works into deep water and of groynes into deep water *east and west* of it.

21. But ONE POSITION for the mouth of a *permanent* canal exists on the peninsula, and that is at Lighthouse Point, where it should be carried out side by side with the groyne into 40 feet water. The groyne might form one side of the canal. A canal from the bay terminating there would retain a permanent opening for ages, if groynes at B, C, D, etc., were constructed as the 'land made' time after time.

22. A canal constructed from the point G to A, and the continuation of the groyne at K to G, would soon enclose a piece of land which would amply pay all the expenses of the undertaking (to be used for the sites of warehouses, storehouses, etc.) and maintain the integrity of the peninsula, and the preservation of the permanent opening into the harbour throughout the year. (See Section No. 1.)

23. In process of time, which might be materially shortened by the construction of simple works, a junction from A to E would be advisable, and thus form a permanent island.

24. If the entrance at the Queen's Wharf were narrowed simultaneously with the construction of the canal from A to G, both openings would remain permanent and unobstructed by bars.

APPENDIX.

Note A.

The materials of which the peninsula beach consist are derived altogether from the drift clay and sand of the tertiary epoch. Precisely the same materials, as regards their mineralogical character, are found to compose a very large portion of the Scarborough Cliffs. The materials consist of—

1st. Very coarse quartz sand.
2nd. Red felspar.
3rd. Black magnetic oxide of iron.
4th. Comminuted calcareous shale, derived from the breaking up of larger fragments found in the blue clay.
5th. Pebbles of quartz, syenite and various other kinds of granite, such as are found in abundance in the drift sand and clay of the Scarborough Cliffs.
6th. Water worn and rounded fragments of shale, containing fossils belonging to the Hudson River group ; some of these fragments are four and five inches in diameter, and one inch thick.

The shale and pebbles constitute a very considerable proportion of the materials composing the peninsula, and are found in abundance at Lighthouse Point. They must have come from the east and travelled along the beach. The specific gravities of some of the sand and materials are given below ; the figures will probably be conclusive as to the possibility of such heavy substances, and of a magnitude which may well confer on them the appellation of 'very coarse sand,' being transported from the *west*, in the absence of powerful currents to propel them through water from 30 to 90 feet deep (between the Humber Bay and the west frontier of the peninsula) :—

Gneiss	2.72
Syenite	2.74
Granite from	2.62 to 2.74

Out of forty kinds of rocks mentioned by Sir Henry de la Beche in his "Researches in Theoretical Geology," only *four* have a specific gravity less than 2.50, or two and a half times heavier than water.

The fossils of the Lower Silurian rock found on the peninsula are derived from the drift clay which reposes immediately above the rock itself. This may be seen, *in situ*, in very many situations near Toronto.

Ice cannot have transported the peninsula materials from the west, for then we should find *boulders*, of which none are to be seen.

But one rational conclusion remains, which is that they have come from the *east*.

Note B.

The late Mr. Roy, C.E., of Toronto, paid considerable attention to the phenomena of Toronto Harbour. He describes it as follows : "The Harbour of Toronto is about $2\frac{3}{4}$ miles in length, from the Government Wharf to the Peninsula Hotel, and about $1\frac{3}{4}$ miles in breadth from the end of Church Street to the peninsula. The water deepens

gradually from the north shore. At the distance of 1,000 feet from the shore it is about 15 feet deep, and at the distance of about half a mile from the shore it is 30 feet deep; further out it deepens to 33 feet, and continues to maintain these depths for about a mile further, when, as we approach the southern peninsula, the depth suddenly declines from 28 to 30 feet water to five, six and seven feet water. The greatest depth at the entrance is 14½ feet, and the width of deep water from the Government Wharf to the buoy is about 800 feet." This was published in the *Monthly Review*, June, 1841.

Note C.

The writer would respectfully suggest to the Harbour Commissioners the propriety of a personal inspection of the Scarborough coast from the east corner of Ashbridge's Bay to Gates' Farm. The wild and romantic beauty of the scenery will well repay the fatigue of the trip. It must be accomplished on foot, and, in order to obtain a clear insight into the phenomena of the coast as connected with the formation of Toronto Harbour, it must be commenced at the east end of Ashbridge's Bay.

The points to which the writer would respectfully direct attention are :—

1st. The nature of the beach at Ashbridge's Bay, and in many instances the very regular *attitude* assumed by the shingle under the influence of the late easterly gale. That attitude consists in the inclination of each piece of shingles with respect to its neighbour, the one to the east reposes as it were on the one to the west of it, and so on, as exhibited in the diagram. In several instances the writer lately observed this arrangement, evidently under the influence of easterly breaking waves.

2nd. Attention is called to a remarkable *remnant* of an ancient beach, about a mile east of Ashbridge's Bay. A fence of a cleared field is in one part placed upon it. Trees of considerable growth are still remaining on it, showing its antiquity. The beach or spit has the form indicated in the diagram.

3rd. Natural groynes of fallen timber occur in this locality and afford a good idea of the extent to which the fallen timber may protect the cliffs.

4th. The configuration of the coast is especially to be noticed where the first or lowest terrace approaches the lake. It will be seen that this terrace, especially when fringed with the tall pines which once covered it, would serve all the purposes of a vast protecting headland from north-easterly and easterly gales, to the present Ashbridge's Bay, and, in the writer's opinion, the first origin of the peninsula was due to this protecting headland.

5th. The enormous gullies are to be particularly noticed, their recent formation, the unstable nature of the materials of which the cliffs are composed, and the certainity of an immensely rapid yearly increase in the quantity of material precipitated into the lake by the falling of the sides of the gullies.

6th. The identity of the mineralogical character which exists between the sand of the cliffs, the beach sand and the sand of the peninsula.

7th. The influence of the total destruction of protecting forest growth on the rapid formation of gullies.

Other subjects worthy of note are embodied in the accompanying report, and do not require to be noticed here.

Note D.

" From the experiments made by the Committee appointed by the British Association, in 1836, it was found that, with a depth of water equal to twelve feet, waves nine inches high and four or five feet long did not sensibly affect the water at the bottom. Waves from 30 to 40 feet long oscillating at intervals of six or eight seconds, produced some effect, but much less than near the surface." (See article WAVES, in the *Penny Cyclopedia*, vol. 27.)

"The agitation of the sea is felt at different depths, in proportion to the magnitude of the waves raised by the friction of the wind. During heavy gales of wind, the depth at which this agitation has been observed, sufficient as it was to shake up fine sediment enough to discolour the water, is about 90 feet."—(*Geological Observer*, p. 112).

"The depths at which the disturbing action of a sea wave can be felt has been estimated even so high as 500 feet on the banks of Newfoundland." *(Emy. Movement des Ondes).* Quoted by Sir H. de la Beche.

The writer is persuaded that the long waves of Lake Ontario, formed by the friction of the wind on an expanse of water equal to 180 miles, are sufficient to move sand at a depth of fifteen feet, especially on a shoaling coast. The construction of groynes on a shoaling sand beach is open to the objection that the groyne itself may occasion such a *reflex* action of the waves as to bring sand from depths where it is affected into deeper water, thus producing *secondary shoals.*

Note E.

The writer does not advance this statement as founded upon indisputable authority. He has heard it stated by persons employed in collecting stone and wood from the Scarborough coast that blue clay is found in ten or twelve feet water outside Ashbridge's Bay, and affords good anchorage ground. On questioning the fishermen in that locality, they said they had *not* observed it. The question is not one of importance, nor has the writer had any opportunity of verifying any statement by personal inspection.

Note F.

During the present spring the writer endeavoured to discover the ancient beach of Lake Ontario alluded to in the text. At the depth of 2 feet, on the borders of the marsh, he found, repeatedly, a washed sand, but did not succeed in finding shingle and pebbles. The high state of the water prevented any search being prosecuted far in the marsh, at a depth of three and four feet.

Note G.

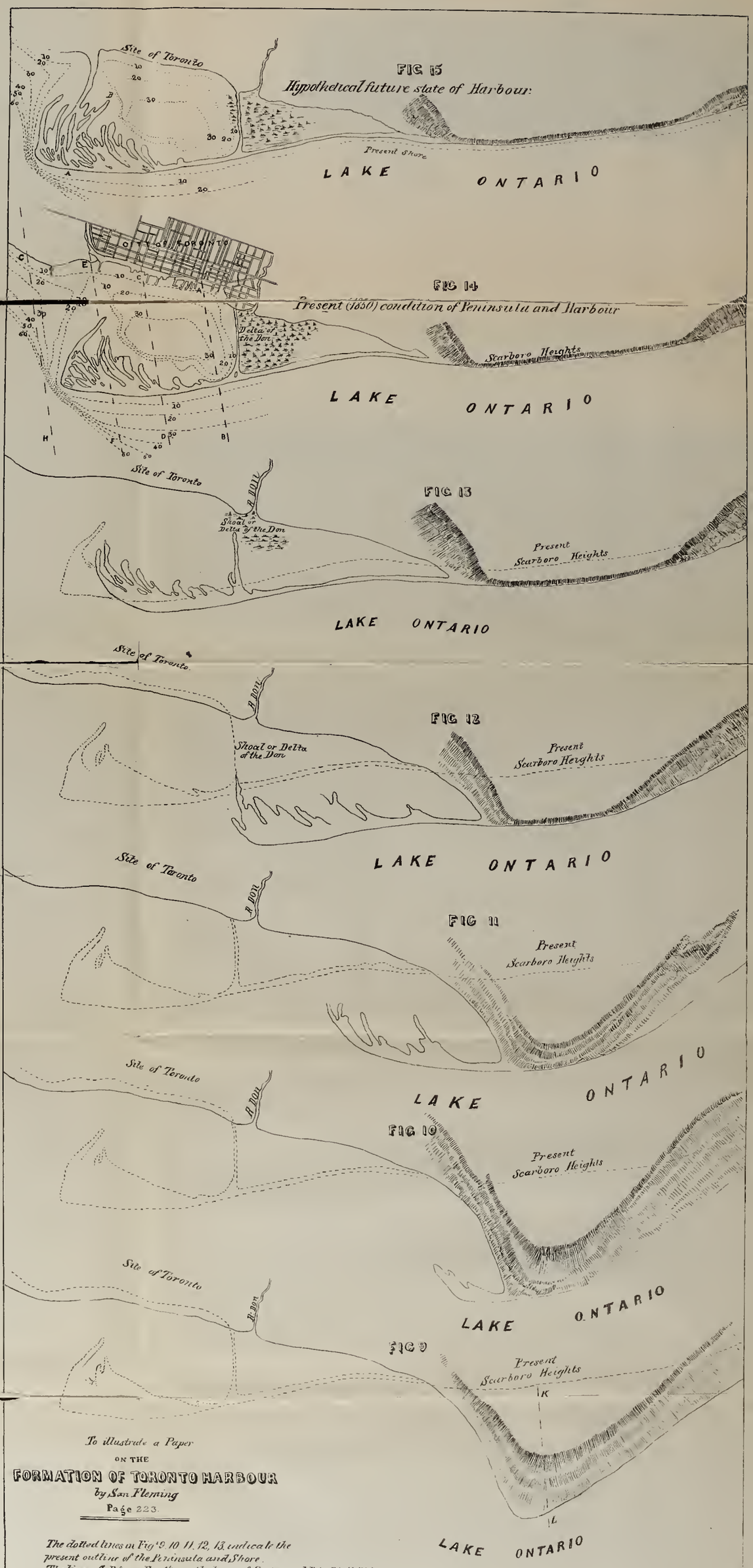
In October, 1853, the writer sketched the appearance of the ridges and new reef at Lighthouse Point, from the summit of the lighthouse, of which diagram No. 10 is a representation. The diagram does not pretend to the accuracy of measurement. It was sketched at that time with the view to illustrate, at some future period, the theory of the formation of the harbour advanced in this Report.

Note H.

The bay sub-aqueous extension of the peninsula has been remodelled and disturbed in many parts. This arises from a circular current which sweeps round the south shore of the bay towards the bar at the mouth, when westerly and south-westerly winds press the waves on to the north shore. Equilibrium is established by means of this current, which is, of course, dependent upon the force of the gales from the quarters mentioned. The late Mr. Roy, C.E., notices this current in the paper before alluded to.

Note I.

The late Dr. Houghton, State Geologist of Michigan, took the level of Lake Michigan in 1819 as his *zero* of comparison, and he noticed in subsequent years the following variations in the level of that lake :—



To illustrate a Paper

ON THE

FORMATION OF TORONTO HARBOUR

by Sandford Fleming

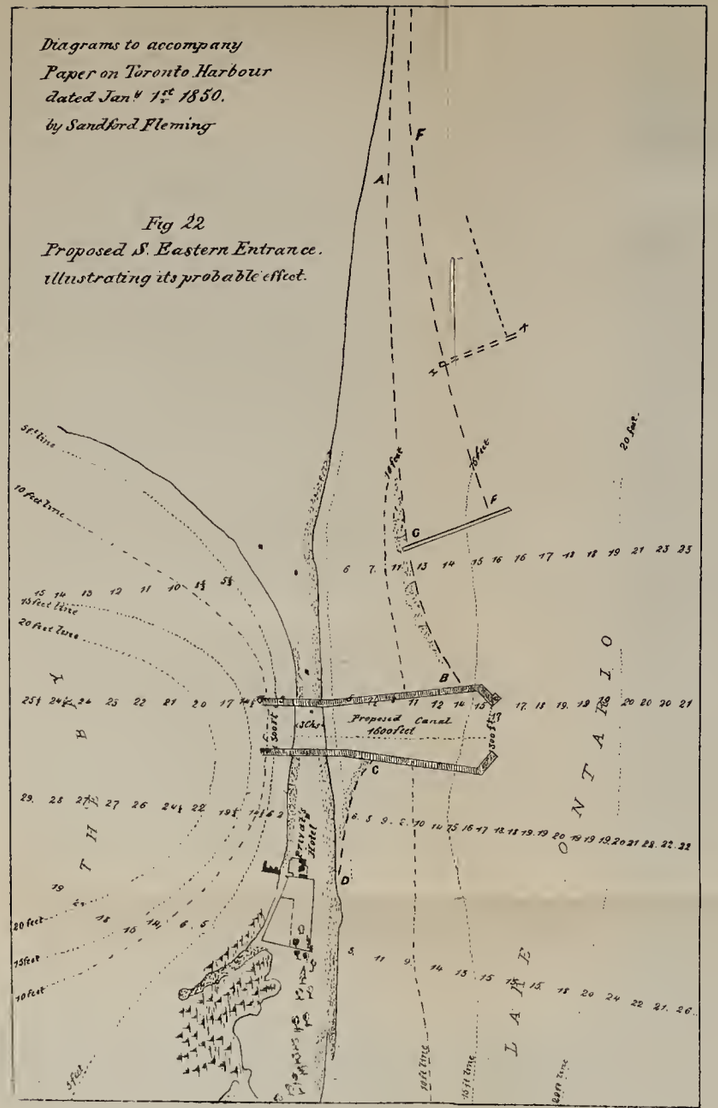
Page 223.

The dotted lines in Fig's 9, 10, 11, 12, 13, indicate the present outline of the Peninsula and Shore.
The lines A B &c in Fig 14 are the lines of Sections A B &c Fig's 16, 17, &c
The dotted lines Fig 14 & 15 are Contours showing depth of 10, 20, 30, 40, 50 & 60 feet of water respectively.

GEO. E. DESBARATS, PHOTO-LITH MONTREAL

Diagrams to accompany
Paper on Toronto Harbour
dated Jan^y 1^st 1850.
by Sandford Fleming

Fig 22
Proposed S. Eastern Entrance.
illustrating its probable effect.


A
F
G
B
C
D
E
Proposed Canal 1600 feet
Entrance to the Harbour
Queens Wharf
Old Garrison
Light House
Government House
Public Store
Powder Magazine
Stone Jetty
Wooden Jetty
Stone Pier
Wooden Pier
Sand Bar
Shoal
Rocks
Ruins
Old Fort
Entrance to Harbour
Summer of Shoal running the Peninsula
Edge of Shoal in 1835
Edge of Shoal in 1796
Edge of Shoal in 1826
Edge of Shoal in 1850
Edge of Shoal in 1850
Edge of Shoal in 1850

LEVEL OF LAKE MICHIGAN.

Years.	Feet.	Inches.	
1819	0	0	Zero.
1830	2	0	
1836	3	8	
1837	4	3	
1838	5	3	
1839	3	11	
1840	2	$7\frac{1}{2}$	

(Report of the State Geologist of Michigan, 1841.)

APPROXIMATE ESTIMATE FOR THE CONSTRUCTION OF WORKS FOR THE PRESERVATION OF TORONTO HARBOUR.

Groyne at Lighthouse Point, about 400 feet long, into 40 feet water	£3,000
Groyne at E.M., into 15 feet water; estimated length, with allowance for low lake levels, 50 chains	2,000
Groyne at mouth of harbour, 100 chains	4,000
Total	£9,000
Estimated expense of constructing a *Canal* into 40 feet water at A, and 20 feet water at G; approximate length, 1,900 yards, width, 200 feet	£15,000
Construction of Groyne from K to G, 100 chains	4,000
Total expense, including Canal and Groynes	£28,000
Amount of available land enclosed by works between the points A, G, F—250 acres at £100 per acre	25,000
Difference	£3,000

(The Canadian Journal, 1855, Vol. III, Appendix.)

TORONTO HARBOUR.—ITS FORMATION AND PRESERVATION.

Read before the Canadian Institute, June 1st., 1850; by SANDFORD FLEMING, C.E.

The origin of the now wealthy and flourishing City of Toronto is, in common with that of many other cities and towns, clearly traceable to certain natural advantages possessed by their localities. A waterfall, or rapid stream, the navigable termination of a river, or its junction with a lake, or other open navigation, will frequently account for the position of a town or village in an agricultural or manufacturing district; but a natural harbour of easy access will generally, if not universally, point out the locality of a thriving commercial nucleus, in all countries open to settlement and civilization.

To none of these circumstances, except the last, can we attribute the origin of Toronto. We have no waterfall—no navigable river—even the soil itself is comparatively barren, and for several miles around, with a few isolated exceptions, unsuited for

agricultural purposes. To the last, therefore, must we ascribe the beginning of Toronto, and to the unequalled excellence of this harbour forming on the north shore of Lake Ontario, the most facile outlet for the productions of the back country, is principally due the rapid and uninterrupted progress in commerce and in wealth of the western capital. To maintain this harbour in its original state, or, if practicable, to improve thereon, so as to ensure a continuance of prosperity, becomes, therefore, of the utmost importance.

The natural basin formed by a sand ridge extending from the western boundary of the Township of Scarborough, embracing in its arms a portion of the great Lake, possesses many of the requisites for a good harbour; it incloses about 1,200 acres of water, entirely free from rocks and shallows, and averaging from 15 to 35 feet in depth, on the wide expanse of which the whole shipping of *all* the Canadian Lakes might safely ride at anchor. During the prevalence of certain winds, however, the basin is not of easy access to sailing craft; and not only is the channel scarcely sufficient to admit the entrance or departure of large vessels, but it is even fast closing up, and, astounding as the assertion may appear to some, will ere many years, unless efficient means of prevention be taken, put a complete stop to all navigation—a bold enough statement, but from ascertained facts a proper inference.

That the entrance to the harbour is fast closing up, I have been led to discover by comparing a series of careful measurements recently made with old charts of various dates. In the sequel this important fact will be clearly shown, and an attempt made to account for it. In the meantime, it may be sufficient to state that a bar has encroached so much on the channel as to make it not more than about half the width it was fifteen years ago. With the view of prescribing an efficient mode to prevent the further accumulation of shoal calculated to prove so detrimental to the future prosperity of the city, it is first requisite to ascertain the cause of the evil, from whence it arises, and investigate the manner of its action—hence the following inquiry into the formation of the peninsula and harbour.

Few persons visiting Toronto for the first time but are struck with the singular appearance of the neck of land or peninsula stretching out into the lake in front of the town, so low that the few small trees growing at wide intervals appear almost springing from the water, and on a nearer approach, so long, so curiously shaped, and so different from the land on shore that many are doubtless led to theorize a little on its formation. Some who have probably arrived in the Province by way of Niagara, and crossed over with their minds filled with contemplations of the mighty cataract, at once and without much consideration attribute to the descending torrents of that river the power of elevating from the depths of the lake, or of carrying across in suspension, the drift deposited here—a theory wild and incapable of defence, though some are bold enough to venture it.

Others again, who have probably arrived from the west, or whose business takes them frequently in that direction, and from the steamer generally calling at the mouths of the various small rivers emptying into the lake between this and Hamilton, may be induced to think that these streams have had the effect of drifting the debris of the uplands outwards, which, with the assistance of an imaginary eastward current of the lake, is carried until meeting a contrary current, supposed to be of the Don, then the matter held in suspension is supposed to have been deposited at their junction line, opposite Toronto. The advocates of this theory have yet to prove that such currents of the lake as these exist in reality; although it is true that currents, outward and inward, over the bar are found, occasionally resembling a slight half-hourly tide; yet, if they have any effect on the bar at all, they must have a tendency rather to diminish than increase the deposit. All these streams, with the exception of the Don, enter the lake nearly at right angles, and it is impossible that they can flow into a large and deep body of water such as exists between their mouths and the point in question without being entirely diffused; nor could the drift brought down by them be carried wholly or chiefly in one particular direction without a most powerful current, but would, if ponderous, be deposited at their outlet, and, if light, would be distributed far and wide. More especially it is reasonable to infer that the peninsula is neither now affected in any way by these western streams and the imaginary currents in conjunction with them, nor *has* been formed by their drift, since the material composing it, sand and gravel, could not, in accordance with existing laws, be held in suspension and transported for miles over still water 60 and 100 feet deep.

Were the deposit, or any part of it, of an argillaceous nature, there would have been some slight reason to think that these streams might have been auxiliaries, but such is not the case.

Others, again, suppose that the peninsula is merely a narrow ledge of rock slightly covered with the sand and gravel which we find on the surface, but this opinion is quite at variance with the general geological features of this part of the country, and to local investigations.

A little consideration of the subject will show that these opinions can only be advanced by those persons who have merely been enabled to make cursory observations, and by those who, knowing the wonderful transporting power of running water when confined as in a river, are inclined to attribute to its agency more than is justly due, and, overlooking the change of circumstances, class effects universally which can only be produced by causes under particular conditions. They being anxious to account for certain results, are contented with a superficial and fallacious reasoning, and assign to the most conspicuous agents of nature that which after a more careful and deeper search would be ascribed to a power less easily observed, but not less active or less potent.

Sir Richard Bonnycastle, in an elaborately drawn up Report, dated 1835, gives it as his opinion that the peninsula "was one of the many ridges deposited at the bottom of a vast lake which existed before the present Ontario and Erie were formed out of its drainage," and "that it had not materially altered for a vast length of time, probably not since it emerged from the waters."

It may be thought presumptuous in me to present anything in opposition to the judgment of that respected and eminent gentleman; but from careful observations and measurements, and a comparison of these with surveys made at different times by others during the last half century, having found that the deposit both above and under water has received additions so extensive, and which so closely resemble in character its older portions, I may be permitted to suggest, instead of the peninsula being a sedimentary deposition of the tertiary periods, as thought by Sir R. Bonnycastle, that the whole of it belongs to the present era, and that at least one of the agents of its formation is at this day as actively engaged in changing and enlarging the outline of the deposit in question as it has been hitherto in gathering together the materials, and modelling them into its present shape.

I shall first endeavour to show that the inferior portion or base of the peninsula has been washed from the valley of the Don by that river at an early date; second, that the materials composing the superior and more recently formed portions have been gradually transported along the shore from the eastward, and that this westward progressive motion of the sand and gravel beach is now the sole cause of the extension and enlargement of the peninsula, and of the danger at present threatening the entrance of the harbour.

First—That the groundwork of the peninsula enclosing the harbour is, or has been, a delta of the River Don.

It is generally believed that at one time Lake Ontario stood at a higher level, and covered a far greater area than it at present occupies. A barrier may then have existed at its outlet, where, probably, the Thousand Islands are now seen, over the top of which the primeval St. Lawrence flowed. This great river, rushing over the barrier with tremendous velocity, would, through course of time, wash away its softer parts and leave standing those numerous isolated rocks and picturesque islands which, now covered with foliage, adorn so much the landscape of that section of the country. If this be not the approved way of accounting for the lowering of the level of the waters, a gradual upheaval of the land generally, or even a subsidence of the ocean, may be brought forward. It is unnecessary for our present purpose, however, to enter into a geological disquisition on this point, if we allow that the whole of the country bordering on Lake Ontario was at one time submerged under the same extensive sheet of water; and that the level of this great lake, or, it may be, this arm of the ocean, was through course of time depressed, and its outline contracted, until it was reduced to the present Ontario; a supposition so strongly supported by the discovery of several ancient beach lines, terraces and parallel ridges in the vicinity of Toronto and other parts of the country at various but corresponding levels, that it may without much difficulty be admitted.

As the land gradually emerged its appearance would be bleak in the extreme; a flat or but slightly undulating surface, unbroken by rivers or ravines and uncovered for a length of time with vegetation; on the ancient shallows of the great lake various kinds of plants would, through course of time, take root, grow up, and wither; the continued reproduction and decay of which would gradually coat the surface with organic matter, and, thus enriching the soil, enable it to produce more luxuriant vegetation. Now (prior to the settlement of the country), after a lapse of many centuries, we find the great hardwood forest growing over soils of an argillaceous character, and the ancient *sand shoals* of the great lake clothed with lofty pine.

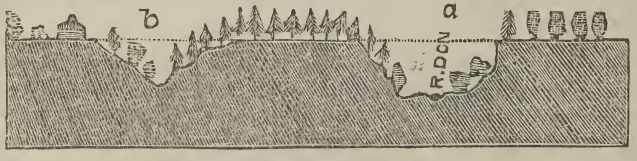
We can easily imagine the general character of the present shores of Lake Ontario when they first became dry land—a vast undulating plain ascending, as at present, from the lake into the interior, but totally devoid of water channels for the surface drainage—here a bed of clay—there a tract of sandy soil; and, as it is only reasonable to suppose that rains fell in those days as at present, the water produced by them on the surface, in flowing from a higher to a lower level, would most easily wash out channels in the softest material; and these little streams, collecting together in their downward course towards the lake, would form the commencement of a river course.

The newly formed rivers, having the same fall towards the lake as the surface itself, their beds being but slightly under it, would be much more rapid than they are now, and, rushing down with violence after thaws and heavy rains, would, proportionally with their greater rapidity during the first years of their existence, be more effective in scooping out the sand drift, and transporting it to the lake; from year to year the water channels would thus grow larger and larger, and although the rivers, as they were depressed, lost much of their force and rapidity, yet, continually undermining the banks and transporting the debris downwards, would, through course of ages, form those deep ravines in which many of them now flow.

That the rivers in this section of the country have originated in this manner is inferred from the fact that they are found almost universally to flow in flat bottomed valléys or ravines, the banks of which are the abrupt terminations of the level country on each side, and that these ravines are generally found where the drift is of a light and sandy nature.

The accompanying section across the River Don, taken a little above the cemetery, will show clearly the first proposition; the second, also, is established by the well known character of the soil of which the banks are composed. The surface of the country extends for miles to the right and left of the river without any material change of level, except where broken by a secondary ravine of a tributary stream. Doubtless, then, the inference is correct as far as regards the Don, and that the dotted line stretching from bank to bank on the drawing, was the surface prior to the scooping out of its channel.

Fig. 1.



Section across the Don about 1½ miles from its mouth.

(a) The valley of the Don, about ¼ of a mile wide, and upwards of 100 feet deep—the river here is on a level with Lake Ontario.

(b) A tributary of the Don, running through Yorkville; it is cut obliquely by the section, and forms a junction with the Don about half a mile further down.

The dotted line is about 120 feet higher than the lake, and the surface maintains very nearly the same level for a long distance on either side in a direction parallel to the shore, with a gentle slope at right angles to it—on part of this slope the City of Toronto is built.

Nor is the Don singular in these respects; of all the streams I am acquainted with to the east and west of Toronto, the same scooping out of the ravines can be shown, and generally the same sandy character of the country immediately traversed, as indicated by the dark green belts of pine running into the interior of the country through the hard-

wood forest, which flourishes better on the heavier soils. And here, without digressing much from the subject, one can scarcely avoid observing very apparent marks of design —the adapting of the pine to grow on soils unfitted for cultivation, and the leading of rivers through pine bearing soils, thus enabling the settler to take advantage of the various properties of running water in conveying and preparing the most useful of all timbers for his manifold purposes.

The valley of the Don is from a quarter to half a mile in width, with abruptly rising banks from 100 to 200 feet and upwards in height, the scooping out of which implies the removal of many hundred millions of cubic yards, a quantity so immeasurably great when brought into comparison with the agent of removal—a stream (when not dammed up) only about 50 feet wide, that it appears altogether irreconcilable with the inference drawn; more especially is it so when we know that the annual quantity of matter brought down by the Don is at present inconsiderable. If, however, we bear in mind that, without assuming a greater volume of water to have flowed in its channel than now, the transporting power of the Don must formerly have been very much greater by reason of its greater descent and rapidity; and, if it can be shown that many ages have elapsed since it first came into existence, the conclusion come to may be taken as rational and correct.

It may seem difficult—nay, almost impossible—to estimate, however roughly, the time which has elapsed since the Don commenced to flow; but if we can arrive at the age of any other river emptying its water into Lake Ontario from a source equally high, the problem is solved. When the great lake already mentioned subsided from its high level, then, and not till then, did the Niagara, the Don, and other cotemporary rivers make their appearance. Since that epoch the Niagara has cut a deep channel for seven miles through the solid rock; its annual recession has been ascertained approximately, and from these data its age has been roughly determined. "We may turn to the deep ravine," says Lyell, "and behold therein a chronometer measuring rudely, yet emphatically, the vast magnitude of the interval of years which separate the present time from the epoch when the Niagara flowed at a higher level."

Thus, then, the Don, coeval with the Niagara, has flowed, according to this great geologist, for a period far too great for the imagination to comprehend, and which one can scarcely venture to name by years; * even allowing that our historical knowledge of the past condition of the falls is far too meagre to estimate with any degree of precision the rate of their retrogression in former ages, yet we cannot but arrive at the conclusion that the chronological age of the Niagara, and consequently of the Don, must be so enormously great that one would think even its fractional part would suffice for the removal of the hundreds of millions of yards of matter by the latter river to the lake, without calling to its aid any unusual phenomena.

Having thus shown that sufficient time may be granted, the Don, therefore, supplies an adequate cause for performing and completing long since the work assigned to it; year after year, during its early history, slowly but constantly hollowing out a channel and removing the former contents of its valley to the lake, the lighter and more soluble matter being held for some time by the water, to be distributed far and wide, the heavier particles, on the other hand, to be deposited near its mouth, in the form of an extensive shoal or delta—the base or ground work of the peninsula, on which again to be deposited a drift from other causes and from another source.

Second, that the peninsula proper has been formed solely by the mechanical action of the waves, that the sand and gravel of which it is composed have been, by this action,

* "Mr. Bakewell calculated that, in the forty years preceding 1830, the Niagara had been going back at the rate of about a yard annually, but I conceive that one foot per year would be a much more probable conjecture, in which case 35,000 years would have been required for the retreat of the falls from the escarpment of Queenston to their present site, if we could assume that the retrograde movement had been uniform throughout. This, however, could not have been the case, as at every step in the process of excavation the height of the precipice, the hardness of the materials at its base, and the quantity of fallen matter to be removed, must have varied. At some points it may have receded much faster than at present, at others much slower, and it would be scarcely possible to decide whether its average progress has been more or less rapid than now." —*Lyell.*

gradually transported from the eastward and deposited on the deltaic shoal of the Don, and that the delta has thus been raised above the surface of the water and extended westward far beyond its original limits.

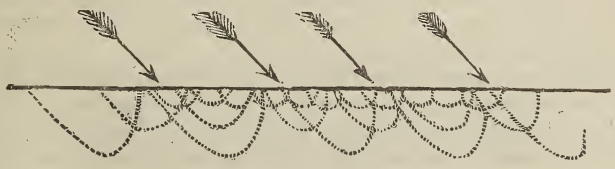
The effects produced by waves on a shore exposed to their action are of various kinds, depending in a great measure on the nature of the beach, the direction of the waves, and their mechanical force: if the shore be of clay, the action is entirely destructive, the banks are undermined and continually caving in, the fine argillaceous particles are taken up by the water, carried out, and deposited after a time at depths unaffected by the motion at the surface; if the shore be of sand or gravel, the effects produced are quite different. When the direction of the waves is not at right angles to the beach a progressive action results, and when the waves break point blank on the shore line with sufficient force the action is destructive, in which case the banks are broken down and the spent wave returns loaded with sand to be deposited outside of the breakers in the form of a shoal generally parallel to the coast; if the soil of which the banks are composed be a mixture of clay and sand the action is both destructive and progressive, the clayey particles are washed out and deposited in still water, while the sand, gravel, and stones are left behind to be moved forward either in one direction or another, and at a rate depending solely on the strength of the impinging waves and the gravity of the materials themselves. On a rocky shore the effects produced are precisely similar, although of course to a much more limited extent; by continual exposure to the wearing action of water and weather a mass is undermined and tumbles down, a portion of the debris is put in progressive motion during every storm when the waves impinge otherwise than at right angles to the shore line, and is moved, according to the locality, in a certain prevailing direction, until meeting a projecting point or other hindrance to its onward progress, thus forming those shingle beaches seen at many places on all rocky shores.

The effects of the destructive action on banks of clay can be traced wherever the shore is entirely of that material; the owners of property along many parts of Lake Ontario can bear testimony to its annual encroachments; and, to come nearer home, many citizens of Toronto must have witnessed the gradual alteration in the form and recession of the clay banks between the old and new garrisons.

The effects of the progressive action can also be witnessed at many points on all the lakes; but at none in a more remarkable degree than at Toronto, although at other places to even a much greater extent. And, since to the peculiar motion of sand and gravel beaches will be attributed not only the extraordinary changes the peninsula is at present undergoing, but even the greater part of the entire formation, it will be necessary to explain fully the nature of it, and give the reasons why the beach should have a tendency to move in one direction in preference to another.

Let us take an example when the direction of the wind forms an acute angle with the shore: a particle of sand resting on the surface is driven forward up the inclined plane of the beach in the direction in which the wave itself moves, the particle either remains at its now elevated position or (as is more usual), sweeps along in a small curve and rolls downwards with the expended wave to a new position, the distance of which from the first will be in proportion to the mechanical force of the wave and its direction; another and each successive wave drives the particle forward in a similar manner, unless by accident it finds a resting place behind some obstruction, or be buried by other particles on the same mission as itself. If we take, instead of a grain of sand, a small pebble, we find that the same wave, or a wave having the same force, moves it a less distance than it does the sand, that larger pebbles, being heavier, make proportionately less progress, and that stones still heavier are moved only when the waves have considerable power. All of these bodies, however, when within the impelling force of the wave, and placed in positions fairly exposed to its direct action, seem to be governed by the same law, and are moved forward a less or greater distance according to their weight or gravity.

Fig. 2.

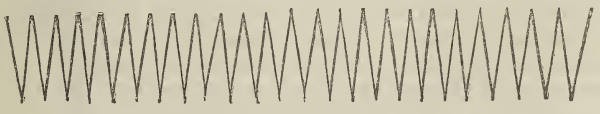


The arrows denote the direction of the waves; the dotted lines show the paths of grains of sand and pebbles.

The zig-zag direction taken by the sand and gravel on the beach is indicated by the various dotted lines on Fig. 2; the smallest one is intended to show the course of a grain of sand, and the two larger lines that of pebbles varying in size. The progressive motion is slightly suspended between each wave, but although intermittent is continued so long as the sea breaks on the shore from the same quarter, and until the moving mass meets with an obstruction, or by reason of a sudden bend or other peculiarity of the shore line is deposited in a position beyond the influence of the waves.

When the waves impinge at right angles to the shore the progressive motion of the beach is theoretically nothing, the various particles of sand are rolled upwards and downwards, changing position only laterally or in the line of direction of the waves; when the waves impinge somewhat less than a right angle the grains of sand move along in a sharp zig-zag line, as

Fig. 3.



in Fig. 3, when much less than a right angle the particles move onward in a long undulatory line, as in Fig. 4, the distance between the points of each indentation being in proportion to the cosine of the angle formed by the direction of the waves and the line of the shore.

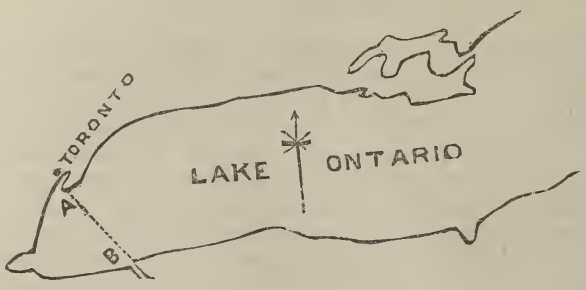
Fig. 4.

Granting that the direction of the waves is governed by that of the wind, it follows that whenever the wind blows from a quarter to the right of a perpendicular to the shore the beach sand is moved to the left and *vice versa*. If, therefore, the wind blew with equal strength and during equal times from all points of the compass throughout the year, and the waves also had at all times the same mechanical force, the sand would at one time move to the right and at another time an equal distance to the left; but, to speak in general terms, the beach would remain ever as it was (excepting the effects of the destructive action). Since the forces never could act simultaneously, we would have, it is true, a constant repetition of complicated motions, zig-zag, undulatory, lateral, progressive and retrograde; but, from their assumed equality and the equal times of their application, there could be no resultant. The mean velocity of the wind may properly enough be taken as equal throughout the year from all points of the compass, since the actual difference, as obtained by observations, will affect the results inappreciably; but the mean force of the waves will not in consequence be equal, as this is greatly influenced by the locality. It is found that the mechanical force of a wave depends chiefly on the

strength of the wind and the extent of open water traversed; allowing, then, that the wind blows equally from all points, it will follow that the resultant of the aggregate forces of the waves impinging at any particular place will be a line lying in a direction opposite to the largest area of open water.

In applying this conclusion to the beach in front of Toronto, we find that the greatest extent of Lake Ontario passed over by winds blowing from any point westward of the perpendicular A B, Fig. 5, does not exceed forty miles, nor is the area of water over twelve hundred square miles, while to the east of A the waves have a fetch of as much

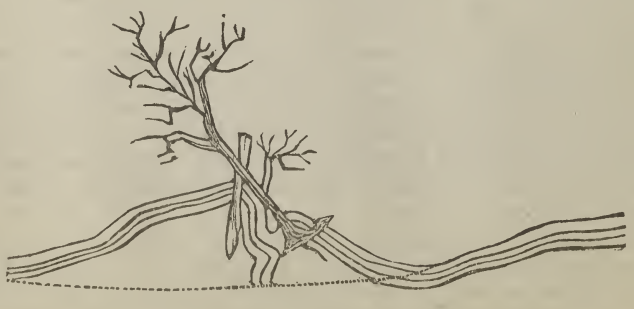
Fig. 5.



as a hundred and eighty miles, over an expanse of water measuring nearly nine thousand square miles; hence then (the duration of the action being taken as equal in both cases), the intensity of the collective forces of waves impinging at A from the eastward is many times greater than that of those from the westward, and the motion of the beach at A must therefore, be westerly; it must of course move with a variable velocity, because the forces are not constant; its path, or rather the path of each particle, undulatory, since the forces act impulsively on the plane of the beach, in combination with gravitation; it must sometimes retrograde, since the direction of the forces is ever changing, and they never act simultaneously, but aggregately; the beach sand, subject to many complicated motions, and acted on by innumerable and incalculable forces, must move absolutely from east to west, and (taking the forces on each side of line A B respectively as positive and negative) with a velocity proportionate to their algebraic sum.

On that portion of the beach successively washed by the waves only, can the progressive motion be proved ocularly, yet doubtless a similar action must be produced between the breakers and the main land all along the shore, and when we consider that the lake is seldom or never entirely at rest, that even during perfect calms, unless continued for several days, a gentle ripple capable of moving sand is found on the shore, throughout the whole year, therefore must the materials composing the beach be continually changing place, and although sometimes moving easterly, yet generally, as proved above, in the contrary direction.

Fig. 6.



The accompanying drawings of natural groynes very strongly confirm the conclusion here come to. They are copied from sketches recently taken (1850) on the spot, between Privat's Hotel and the Scarborough Heights. Fig. 6 was formed by the falling of a tree opposite a fisherman's hut, east of the Narrows, on a passing log; the outer end of the tree was supported by its branches: about one-half of the log was floating, but kept stationary by the tree: the remaining half rested on the surface, and enabled the sand to accumulate at its easterly side. Figs. 7 and 8 appear also to have been formed in a similar manner. They were found on that part of the shore between Ashbridge's Bay and the Scarborough Heights. The dotted lines indicate

Fig. 7.

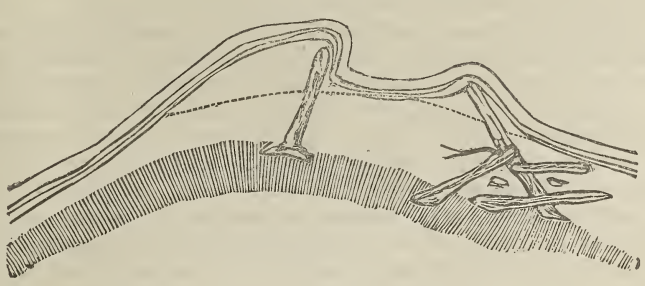
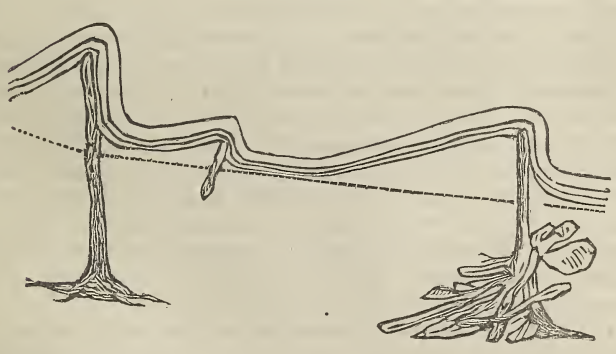


Fig. 8.



Sketches of Natural Groynes.

what was supposed to be the original water mark. In all cases, the water was from one to two feet deep on the westerly side of the logs, and in several instances the sand was five or six inches above their upper surface on the easterly side. These groynes, formed by accident, show very clearly the results of the westward motion of the beach, and, although simple in the extreme, are natural models from which may be designed other contrivances for the retention of the moving sand, and will be referred to hereafter in treating of the preservation of the harbour.

In addition to these indications of the westward motion of the beach, it may be observed that, on an examination of the mouth of several small streams discharging into the lake east of Ashbridge's Bay, it is found that, whatever be their general direction inland, so soon as they intersect the sand beach their course is westward. In most cases they run parallel to the shore, separated from it by a small ridge of sand, and ultimately discharge into the lake some distance west from the point where they leave the woods.

We have, also, palpable and positive proof of the westward motion of the beach in the extension of the peninsula itself in that direction. Joseph Bouchette, late Surveyor General of the province, made a survey of Toronto Harbour in 1796, a reduced plan of

which was published in 1815, along with his work on Canada. At the date of the survey, that part of the peninsula on which the lighthouse is erected, was then the margin of the lake. Since that time, one sand ridge after another has been washed up, until now, after a lapse of only fifty-four years, a tract measuring upwards of thirty acres has been added, and the lake is now distant from the lighthouse about eighteen chains.

The general appearance of this recent addition to the peninsula resembles so closely other older portions, and its geological character is so clearly identical, not only with the adjacent parts, but also with the whole formation, that we may very properly infer they are each and all produced by the same causes. Admitting, then—and it is indisputable—that this enlargement of the lighthouse point is due to the progressive motion of the beach sand through the mechanical agency of the waves from the eastward, we come to the conclusion that the whole peninsula is the result of the same action, continued through past ages, and traceable to the same eastward source.

Arrived at this conclusion, we are naturally led to inquire whence has the abundant supply of material for so extensive a deposit been obtained. About five miles east of Toronto, a high bluff, known as the Scarborough Heights, stretches along the shore for several miles. The bluff is about three hundred feet high, and is chiefly composed of sand, with at intervals a stratum of clay. It is known by the farmers residing in the neighbourhood to recede ten or twelve feet annually at the present day. Further eastward, the coast has a low aspect, and is of a soil capable of providing but little of the substances of which sand and gravel beaches are composed. Moreover, by contouring the country bordering on this high cliff, it is found that the lines betoken a former great projection lakeward, of which Fig. 9 (see plates) is an ideal outline, and Fig. 16 a sectional sketch on the line KL at right angles to the shore. For these reasons, then, we are induced to fix upon this point as the locality from whence has been drifted the materials forming the deposit in question.

Founded on demonstrative and probable evidence, here in part set forth, I will now venture to lay before you what I believe to be a correct theory of the gradual formation of that singular deposit which has provided for Toronto so good a harbour.

On the subsidence of Lake Ontario from a high to its present level, the land fell in easy slopes to the water's edge, and the gradual descending surface lines were continued outward under water; the abrupt terminations of the land along the boundary of the lake having been formed by its encroachments through a long course of ages, the promontories which formerly projected have been rounded off by the destructive influence of the elements. The sand and clay of which they consisted, and which lay between the ancient and present margins of the water, having been removed to other parts, the clay carried out and stratified at the bottom of the lake, and the sand formed into new deposits, kindred to the one under discussion.

Referring to Fig. 16, we have an illustration of this as applied to the Scarborough Heights. K represents the present position of the cliff, and L the supposed former shore of the lake, the point of land extending from K to L, (Fig. 9) having been removed by waves.

Figs. 9, 10, 11, 12 and 13, are sketches of the deposit at several periods prior to and during its formation. The first shows the supposed original outline of the lake immediately after its subsidence, prior to any encroachments or changes of the shore line; the second, a small spit running westerly from the Scarborough promontory; the third and fourth, farther extensions of this spit, and wearing away of the promontory. At this period (Fig. 12) the River Don has brought down a large quantity of drift from its valley, as explained in the first part of this paper, and the lake deposit is now going on over the shoal water. Only a small portion of the spit thrown up at this period now exists, the remainder having been encroached on and moved westerly as the heights at Scarborough receded. The portion referred to is a narrow ridge running landward to the west of the Don. It may now be seen stretching from near the windmill outward, and separating the marsh from the harbour.

Fig. 13 shows still further enroachments on the land at Scarborough, the almost entire removal of the spit shown by Fig. 12, and the advancement of the peninsula westward.

Fig. 14 represents the present state of the deposit. The dotted lines are contours (explained on the plate) showing the rapid progress of the shoal landward at the western boundary of the harbour. Its edge between the point of the peninsula above water and the mainland, at the Queen's Wharf, may be taken at the ten feet water line, within which it immediately rises, and gives a depth of about four feet only along the eastern side, and from six to thirty inches along its western boundary.

Figs. 17, 18, 19 and 20 are sections across the harbour and peninsula, on the lines G H, E F, C D, and A B, drawn on Fig. 14. These show clearly, without unnecessary explanation, the nature and limits of the deposit. Fig. 20 runs from the foot of George Street southerly throught that point of the Narrows proposed for the eastern entrance to the harbour hereafter mentioned; Fig. 19 on a line parallel to the first, from the Parliament Buildings southerly; Fig. 18 from near the Queen's Wharf, directly across the shoal at the entrance; this, as well as the last, cuts several of the many ridges of sand, with long narrow ponds between, by which the upper surface of the formation is characterized. Fig. 17 runs from the old French Fort, parallel to the other sections, intersecting no portion of the deposit, but passing very close to its western limit at the Lighthouse Point, in sixty feet water. The depth of water, increasing as the deposit was extended westerly, accounts very satisfactorily for its spreading so much towards the north. Although an equal amount of sand may annually have been brought forward, yet, as the deposit was forced out into increasing depths of water, this rate of extension westerly would in proportion be diminished, thus allowing the southerly waves more and more time to act in moving the deposit towards the north.

In the manner above explained it is argued that the peninsula has been formed, is still undergoing great changes, and is even now receiving large annual additions from the same source. It seems, too, from what will shortly be laid before you, that the same natural agents which have raised up a breakwater, and formed one of the most capacious harbours on the lake, are as actively engaged in its destruction, by fencing in, as it were, the whole smooth water basin they have made, and justify the inference that, if left entirely to themselves, will, at some future period, unite the peninsula to the mainland west of the Queen's Wharf, in the same manner as it was originally connected by the ridge from near Privats' to the windmill. This stage of the deposit is illustrated by Fig. 15, at which period the surplus water of the Don would, in all probability, find egress over the bar by a shallow channel, fluctuating in position as well as depth during every southerly gale, or by such gaps as are occasionally opened in the narrow belt of sand separating Ashbridge's Bay from the main lake.

The progressive motion of the beach, observable only on close examination, and apparently of little moment, is, when continued during incalculable periods of time, thus proved to be productive of very extraordinary results. Nor is it confined to this neighbourhood, for we discover unmistakable indications of its operations along the shores of all the great inland lakes.

Round Lake Ontario its effects can be traced at Burlington Beach, the mouth of the Niagara River, Presqu' Isle, Cobourg, Port Hope, Windsor Bay, and at innumerable points along the east and south boundaries of the lake.

Round Lake Erie we see its results at Sandusky Bay, Point aux Pins, Long Point, Port Colborne, Buffalo, and at Erie.

At Saginaw Bay, Thunder Bay, Rivières aux Sable, north and south, at Nottawasaga, and the Christian Islands, on Lake Huron.

Round Lake Superior we also have many examples of a like kind; at Fond du Lac a gravel beach resembling in a marked degree, both in appearance and position, the Burlington Beach near Hamilton; at the mouth of the Bad River, and at Point Iroquois, also, are found beach formations.

Many of these closely resemble in outline the peninsula at Toronto. Some of them are kindred to the hypothetical stage denoted by Fig. 15; all of them are identical in geological character, and exemplify the working of one of nature's ever active agencies, co-existent and co-extensive with the lakes themselves. One fact which very strongly confirms the theory of the formation of the peninsula here propounded is worthy of notice: all the examples above mentioned invariably conform with the rule laid down—the trend of the deposits bearing in a direction opposite to the longest fetch of the waves,

or the largest area of open water traversed. The entire absence of boulders is also very remarkable, and whenever gravel forms part of the drift, the largest sized is generally found nearest its source, the finest kinds being at the greatest distances. This circumstance is explained by Fig. 2, and the accompanying remarks, which show that small bodies are moved onwards with the greatest facility. Large boulders, in consequence of being able to resist the mechanical force of the waves, remain at rest, and, therefore, can form no part of beach formations.

To arrive at a knowledge of those changes more particularly referred to which have taken place on the shoal at the mouth of the harbour, I have, with permission, carefully examined the old maps and charts in the Surveyor General and Ordnance Departments; Many of them are wanting in detail, and in this respect of little service to the inquiry; others are of considerable value, the most reliable of which appear to be the charts of Bouchette, Bayfield, and Bonnycastle, dated respectively 1796, 1828, and 1835; for, although they do not profess to much nicety of detail, yet, emanating from these sources, we have no reason to doubt their general accuracy. Fig. 2 shows the position of the shoal at the several dates of these charts, and as it now exists; the soundings have reference to its present state. I have much to regret being as yet unsuccessful in procuring a copy of one very old chart, the possession of which would be invaluable, seeing that it is, without doubt, the earliest record of Toronto Harbour in existence. This chart is said to have been made by a corps of engineers who accompanied the first pioneers from France, nearly 200 years ago. A copy, perhaps the only one on the continent, was unfortunately destroyed with the Parliament Buildings in Montreal, in 1849. The original is supposed to be deposited in a Jesuit college in Paris.

On comparing the charts of Bouchette, Bayfield, and Bonnycastle with my own from a recent survey, showing the state of the peninsula at the present time, we obtain results as follows:—

First, that the channel between ten feet water lines was,

In 1796, about	480	yards wide.
" 1828, "	310	"
" 1835, "	260	"
" 1850, "	120	"

Second, that the quantity of sand deposited at the south side of the entrance, by an approximate estimate, is as follows:—

From 1796 to 1849-50 nearly 660,000 cubic yards, being in 53 years about 12,400 yards per annum.

From 1828 to 1849 nearly 235,000 cubic yards, being in 21 years about 11,200 yards per annum.

From 1835 to 1849 nearly 155,000 cubic yards, being in 14 years about 11,000 yards per annum.

The alarming progress of the shoal landward is, from these figures, very apparent. Fifty-three years ago the entrance is shown to have been four times its present width, and fourteen years ago more than double, thus decreasing at the rate of from seven to ten yards annually, by the deposit of about 11,000 cubic yards.

If such be the case, and it is founded on the most authentic information relative to the past condition of the harbour as yet in our possession, we have substantial reasons for believing that if left unheeded it will, in ten or twelve years, be inaccessible except to the smallest craft.

The extention of the shoal may be attributed to the same causes which are proved to have formed the whole peninsula. The beach sand having reached the Lighthouse Point cannot, by reason of the great depth of water, as shown by the contour lines, Fig. 14, make much progess in extending the peninsula from thence westerly; there is, therefore, nothing or at least not much to prevent the southerly waves from acting in full play, they having a fetch of forty miles in opposition to the northerly immediately off the land,

and, washing along the bar (scarcely under water) towards the north, "dump," as it were, periodically large quantities of sand into the channel.

Certain outward and inward currents occasionally exist at the entrance, caused probably by gales slightly varying the level of certain portions of the lake, or, as it is also supposed, by local variations of the atmospheric pressure on its surface; these may assist to a limited extent in prolonging the existence of the channel, but, from all the observations I have as yet been able to make, they appear to be surface currents only, having little or no appreciable effect five or six feet under water; even this supposition, therefore, is very problematical.

ITS PRESERVATION.

Having by sufficient evidence set forth the probability, if not the certainty, of an early destruction of the harbour by the damming up of its entrance, we may now proceed to be practical, and, so far as the commercial interests of Toronto are concerned, the vitally important part of the inquiry, and endeavour to obtain a satisfactory answer to the query—How can such a catastrophe be obviated or indefinitely postponed? A problem which becomes of comparative easy solution when the immediate cause of the evil is set beyond a doubt, and the nature of its operations clearly ascertained

To keep those harbour channels, subject to obstruction from moving sand bars, in a navigable condition, three expedients are generally resorted to: First, continuous or periodical dredging; second, the application of a scour to remove the bar as it is formed; third, the construction of such works as are calculated to prevent the deposition of sand in the channels, by retaining it at a distance when its source is known, or by diverting it to those points where depth of water is not essentially necessary.

The first is often applied as a temporary remedy, and as such may at times be viewed as a fit expedient, but to employ it as the lasting counteracter of a constantly increasing evil, is to adopt an indubitable source of unceasing attention and endless outlay; it should accordingly be dreaded as a permanent restorative, and employed only by compulsion from unusual difficulty in the application of other measures that are generally less costly and always more satisfactory.

The second is obtained at *marine* ports by taking advantage of the tidal fluctuations, and is generally produced twice each day by using the currents of rivers at low tide, or by holding up the sea water in large artificial basins at flood, then concentrating and guiding it to the bar at ebb. The impracticability of procuring a scour on Lake Ontario from tidal fluctuations must be admitted, since practically there are none; true it is we have a gradual rise and fall of about two feet annually, and at times successive oscillations in level to the extent of several inches, much resembling small tidal waves; but the latter, although they give to the surface water at the entrance of the harbour a perceptible current, are too rare and too feeble to be of any real value. Nor have we at Toronto a river sufficient for the service, for the Don has hitherto failed to keep open its own channel to a greater depth than two or three feet. Indeed, I feel quite convinced that all attempts on these inland waters to keep permanently open those harbour channels much exposed to beach drifts by other than the largest class of rivers must, sooner or later prove ineffectual. The currents of the Nottawasaga, of the Sable, and of the Saugeen, are unable to keep open to a sufficient depth or width the mouths of those rivers, and yet they are in volume from ten to twenty times greater than the Don.

The third remedy can always be advantageously employed in cases when the obstructions are the natural results of moving beaches, and when the works are located and executed with proper care they usually answer a good purpose; the second is often, after great outlay under favourable circumstances, of doubtful efficacy. In the case of Toronto, even if we had at command a current capable of removing the sand on its arrival at the point of the shoal, I question very much if it should be considered as more than an auxiliary, since it would of necessity tend to spread the deposit, and thus, although injuring the channel in a less degree, would impair the harbour generally by lessening in depth the approach to it. Without doubt the steps likely to confer the greatest security, and hence the most advisable to be taken, are those which are calculated to keep the drift at a distance from that point where it is not wanted.

I, therefore, beg leave to submit for your consideration the following preventive and remedial measures :—

1st. That a groyne should be constructed at the Lighthouse Point, from the shore outward, to 8 or 9 feet water, for the retention of the moving sand, on the principle of those very simple natural ones shown by Figs. 6, 7 and 8.

2nd. That an auxiliary groyne be run westerly across the outer edge of the shallows, a little to the south of Gibraltar Point.

3rd. That a pier or breakwater be built along the south side of the channel, as shown on Fig. 21, increasing the navigable water to six hundred feet by cutting off the point of the shoal north of the proposed line of pier.

The third alone would probably suffice for many years to keep the channel perfectly free from deposit; but the sand, if not retained at the Lighthouse Point, would, as at present, be moved northward by the southerly waves, and would gradually accumulate to such an extent as to fill up the whole space along the south side of the pier until ultimately rounding its extremities. To effectually prevent this, the first and second should also be constructed. The first would divert the drift westerly into deep water, where the navigation could never practically be obstructed; and the second groyne, placed about midway between the first and third, would have the effect of counteracting all progressive action along the west end of the peninsula.

If the destruction of the harbour entrance, and the formation of the peninsula generally, be satisfactorily determined, I think it is equally conclusive that these works, or works of the same character, would, if established in due time, be exercised to a very beneficial result—the preservation of the harbour for an indefinitely long period.

There are other evils which, if they affect the salubrity of the city more immediately than they prove detrimental to the harbour, are not, on that account, of the less consequence. The Don annually transports, even at this day, considerable quantities of silt from the interior of the country to the marsh, and during freshets a portion escapes from thence into the harbour through the openings in the beach between the windmill and Privat's, tending, of course, when deposited in the basin, to lessen its depth. All the drains and sewers empty into the bay, making it, in truth, the grand cess-pool for a population of probably 30,000 inhabitants, with their horses and cattle. The sewers of necessity bring down no inconsiderable portion of solid matter, impairing greatly the purity of the water in the harbour, as well as gradually lessening its depth. This evil, increasing in a proportionate ratio to the growth of the city, might be greatly ameliorated, if not almost totally removed, by the construction of a main sewer along the whole city front eastward to the marsh. Into this sewer all the lateral ones from the north, and the drainage of gas, chemical, and other such like works, should be made to discharge. The feculent mixtures produced would thus be collected and conveyed to a distant point, where, by similar operations to those now ripening in Britain, which will strip them not only of their noxious, but even of their offensive characters, might be profitably converted into a marketable commodity of the highest value to the farmer.

The prejudicial effect of the Don on the depth of the harbour may also be destroyed by closing its present outlet, and forming an opening of sufficient capacity in the beach, separating the main lake from Ashbridge's Bay.

All proposed works relative to the improvement of the harbour should be carefully considered before any be proceeded with, lest some of them may interfere with preservative measures, or the general improvement of the whole. It may not be out of place, therefore, to consider briefly another proposition which, for many years past has engaged public attention, perhaps more than any other, in connection with the harbour, viz: the forming of an eastern entrance.

Judging from the following paragraph, extracted from the *Courier* newspaper, dated 5th March, 1835, the project was seriously talked of fifteen years ago :—

"Cut Across the Peninsula.—A respectable meeting of the friends to this measure was held on Thursday evening at the Commercial Hotel, when a select committee was appointed to request the Governor to name an engineer, and also to request the Mayor and Corporation to name another to

meet him, for the purpose of reporting on the probable result of the cut. The committee waited on His Excellency this morning, who very readily named Captain Bonnycastle, at the same time expressing a hope that a measure so adapted to promote the health of the city would be carried into effect. His Excellency also promised to do all in his power to put the entire marsh at the disposal of a company, with a view to its being reclaimed as far as it is possible to do so. There is every reason to expect that the Corporation will take the same view of the case; and if the report of the engineers shall be favourable, a number of wealthy merchants and others in the city have expressed their intention to take up a sufficient quantity of stock to complete the undertaking."

A few months thereafter, the following was gazetted amongst the Notices of Public Improvements:—

"TAKE NOTICE.—The inhabitants of the City of Toronto will make application to the next session of the Provincial Parliament to incorporate them into a company for the purpose of opening a ship navigation through the neck of the peninsula between the lake and the Bay of Toronto.

"TORONTO, August 1st, 1835."

It is unnecessary to say that the contemplated improvement has not been carried out. The spirits of the projectors were probably damped, and their stock book laid aside, after the opinions of the engineers appointed to examine were made public. I have only been able to obtain the perusal of one of these documents, but am informed that the report of the gentlemen appointed by the Corporation was even less favourable.

Captain Bonnycastle says, relative to cutting a navigable canal through the peninsula:—

"If this should be done without due consideration, the barrier which nature has interposed for the preservation of a harbour formed probably by the cutting action of the Don when it was a larger river, which it only requires to look at its banks to convince one's self that it anciently was, will be thrown down, and the harbour entirely destroyed.

"The reasons to be assigned for this opinion are as follows:—

"The southern face of the peninsula, a low ridge of sand, is bordered to some distance out, excepting near the Narrows, by large and fluctuating shoals, well known to the fishermen, who have so recently established a profitable trade on them.

"The force of the easterly and westerly gales on these shoals and the bounding shore is tremendous, as every person in Toronto has frequent opportunities of hearing, even at the great distance which the city is from them.

"Should a navigable canal, without due restrictions, be cut through the slender belt which divides the waters of the lake from the basin, all the millions of tons of large shingle, small, rounded and angular fragments of granite and other hard rocks which line the beach, will be put in motion—will break down by their erosive power any barrier opposed to them—will carry before them the whole extent of the Narrows, and perhaps penetrate through the ponds, fill the basin, and convert it into a fresh sand bank." This, he goes on to show, might be produced by a current through the canal, and further states, "It might, in fact, tear away all the strip of beach along the western or bay shore of the great marsh, and let the whole of that body of the mud of ages into the basin.

"It is argued that all this may be avoided by running out extensive piers into the lake, and forming a strong embankment along the Ontario face of the Narrows. These, if placed in such situations as to break off the strength of the easterly or westerly swells, will do much towards it, but it will be also necessary to make the canal of stone, to puddle its sides to a considerable thickness or extent, to make it narrow, and to place gates both at its entrance and exit.

"With these precautions, there can be no harm in trying the experiment."

Although entirely concurring with Captain Bonnycastle in the expediency of closing up the present outlets of the Don, and of conveying the whole sewage of the city to the marsh, yet, having already, with all due respect, expressed my reasons for differing from the view he takes of the formation of the harbour, and since conclusions on this point affect directly and very materially the consideration of all works of improvement immediately connected with the peninsula, I may also be permitted to entertain opinions not

altogether coinciding with his as to the probable effects of the proposed south-eastern entrance, and its mode of construction.

Knowing the nature of the action of the beach at the proposed site of the canal—and I think it is established beyond a doubt—there can be no possible danger of any part of the peninsula being torn away, or the basin within being filled up with sand, if proper steps be taken to counteract such action. This action is chiefly the progressive motion of the beach, which would effectually be suspended for many years by the piers of the canal themselves, constructed with cribwork in the ordinary manner. The canal need neither be narrow, as suggested, nor provided with gates, since the former would increase the danger in entering, while the latter would add to the cost and inconvenience, and no benefit could result from either.

Fig. 22 shows the proposed position of the canal. Its extreme length, from 13 feet in the bay, to 17 feet in the lake, is 1,600 feet, with a width of 300 feet. The eastern pier, presenting an obstruction to the motion of the beach westward, would, acting as a groyne, retain it permanently at its eastern side; the western pier, on the other hand, would be exercised to a similar result in suspending the retrograde movement. The sand gradually accumulating in the space north of the lines AB and DC, would thus strengthen the peninsula at its weakest point, and remove any danger which may be feared from the destruction of the narrow separating ridge between the lake and the harbour. The entire destruction of the isthmus, although hypothetical, is, nevertheless, a contingency advisable to guard against. Openings have repeatedly been forced through the ridge bounding Ashbridge's Bay by gales point blank on the beach; these, having a destructive action only, might produce a similar result here. If, at the same period, the base of the Scarborough Heights became partially protected from the fury of the waves by the lodgment of an unusual number of trees, or the falling of boulders from the cliffs above, the supply of sand from the east would, for a time, be diminished, the gap would remain open and liable to be widened by every southerly wind. The peninsula would thus be converted into an island, resembling its kindred formation "Long Point" on Lake Erie.

Through course of time (roughly estimated at about 20 years) the sand accumulating east of the canal would reach the line AB, and, ultimately, round the piers; then it would be necessary to make another provision for its retention—a groyne on the line GF would effect this object and retain the sand for another period, until it had reached as far as the line EF. The canal might thus be kept open by repeating the construction of groynes like EF and HK *ad infinitum*, from time to time, as necessity required; or the same purpose may be effected by simply extending the eastern pier as the sand accumulated outward along its eastern side.

The canal, having thus the effect of widening the isthmus and removing all probability of its destruction, would, besides being a great accommodation to sailing craft in adverse winds, and to *steam vessels at all times*, likely enough prove of service in another respect. The purity of the water in the bay is ever liable to be impaired by the vessels in dock, and its close proximity to the city. The canal would provide an additional opening for the ingress and egress of the slight tidal waves formerly referred to, doubtless presenting greater facilities for the renewal of the water in the harbour on its occasional fluctuations in level.

From certain simple and well established premises, it has been my purpose to draw reasonable conclusions, which in recapitulation may be briefly stated as follows :—

First, that the foundation of the peninsula enclosing the harbour may be attributed, in its early stages, to the *debris* of the country traversed by the Don, in connection with a drift from an ancient promontory at Scarborough.

Second, that the drift from Scarborough has supplied and gradually deposited the main part, if not the whole of the materials composing the more recent portions of the formation.

Third, that the drift is in consequence of the singular progressive action given to sand and gravel beaches, under certain circumstances, by the waves.

Fourth, that the harbour is daily being impaired by its chief agent of formation, and that its only entrance is threatened with early destruction by the same cause.

Fifth, that its preservation may be permanently effected by the construction of groynes at well selected points.

Sixth, that the dangers to be feared from the silt of the Don and the sewerage of the city, although remote, would, taken in conjunction with the increasing deleterious effects of the latter on the water of the harbour, warrant their total exclusion.

Seventh, that the construction of a south-eastern entrance would be a great accommodation to the shipping, may improve the purity of the bay water, and, if properly executed, have no effect in lessening its depth; but would only assist in the preservation of the harbour so far as its piers, acting as groynes, might retard the sand, widen the narrows, and thus strengthen the weak point of the peninsula.

Although the preventive and remedial measures are founded on what I believe to be correct deductions, yet, seeing that they differ materially from those advanced by others who have considered the subject, they are presented on that account with some degree of timidity. I purpose, however, with the view of either confirming or modifying the conclusions arrived at, to continue a series of observations, carefully noting the various changes going on; and will, if deemed worthy, take much pleasure in laying the results of such observations before the Institute at a future time.

The foregoing with the following formed the Report submitted by Mr. Fleming, which obtained the second prize of Seventy-five pounds.

By the perusal of that paper, it will be found to be chiefly founded on a very laborious and expensive survey made between August, 1849, and the spring of 1850. Without such a survey, I am inclined to think any opinions on the subject would be too speculative to be of much practical value, and I may therefore claim that in this competition due consideration be given to my previous labours, of which this Report may be considered as the result.

All the leading characteristics of the peninsula were laid down by careful triangulations—the shoals lakeward by soundings and angular intersections, and the nature of the bed of the basin ascertained by boring and soundings through the ice, and chaining on its surface; these soundings amount to between two and three thousand, and are reduced to an approximate mean level of Lake Ontario, ascertained in conjunction with Capt. Lefroy, from a series of lake levels taken by his directions during several years. The chart made from this survey is a necessary accompaniment of this Report, and I shall be happy to submit it any time for your inspection; but since I have yet hopes of refunding myself (by its publication) for the cost of its production, you will be pleased for the present, therefore, to consider the copyright secured to me.

The results deduced from the evidence set forth in the paper referred to were so startling that on the occasion when I had the honour of laying it before the Institute I determined to lose no opportunities of verifying or contradicting them. The promise then made I have not failed to make good, having from time to time instrumentally observed the various natural changes in progress; and, since those observations were made with the greatest care, and appear to be of considerable value, I am gratified by the opportunity now afforded me of laying them before you. Being led to believe that my views on this subject are at variance with the acknowledged opinions of parties officially connected with the harbour, I have been especially careful to review the grounds of my decisions, and have discovered no reason for departing from the opinions originally expressed by me the paper referred to, but, on the contrary, have been strengthened in them by subsequent and very recent investigations. I, therefore, frankly submit to you my convictions, taking leave to remark that they are based on well ascertained facts capable of positive proof, and not at all on any of the many prevailing rumours and baseless suppositions which are current amongst us in relation to this harbour formation and its present state.

It may be laid down as an axiom that a right understanding of the causes of the formation of the harbour and of the continual changes it is undergoing is essential to the

consideration of any preservative measures. The document attached enters so fully into this part of the question that it appears to me unnecessary to enlarge thereon, more especially since four years additional observation very materially strengthen and go far to confirm the opinions therein promulgated. I will first, then, explain the nature and results of the instrumental observations recently made.

My attention has lately been more particularly bestowed on the sub-aqueous operations at the entrance, not that they are here most active, but because they are least conspicuous and most to be dreaded. To ensure accuracy the following steps were taken: The approximate mean level was referred to a permanent stone benchmark, the stone step of one of the cellar doors of the Custom House, under which it was found to be six feet and one inch. The mean being only approximate and subject to after corrections, six feet under this benchmark was assumed as a good datum, and to which all soundings were reduced. Scales were established at various points with zeros corresponding in level.

A floating chain 462 feet in length, made of long wooden rods linked together with iron rings was constructed for measuring with the greatest possible accuracy horizontal distances on the surface of the water.

An iron tripod was erected on the shoal as a fixed point from whence to stretch the chain and measure distances.

A graduated standard sounding pole was used for measuring depths.

A self acting tide guage was constructed for the purpose of giving a continuous register of every fluctuation in level, and affording a means of arriving at the extent, nature, and precise number of fluctuations, of which so little is known, and on which phenomena so much value is placed by many, as being the cause of currents in your harbour. I regret to state, however, that I have as yet been unable to apply this instrument to its purpose, for, being unrecognized and unassisted in this service, I could find no position in which to establish it, nor have my means justified me in incurring the necessary attendances for observation during my own absence from the city.

Thus provided (omitting the last mentioned instrument), I commenced my second survey on the 27th November, 1850, and was to a certain extent very successful; but during the night some evil disposed unknown person, removed the iron tripod stationed on the shoal, leaving to my regret, the survey only partially finished, and thus vexatiously disheartened I had on after occasions to adopt other, though perhaps not much less accurate measures.

Two theodolites were placed at stations as far apart as possible on the Queen's Wharf, their distance being carefully measured, and the points where soundings were made ascertained by a proper code of signals and angular intersections. The soundings were in three cases likewise made by the standard rod, and all were carefully reduced to the same datum, the assumed approximate mean level.

In this manner surveys were again made on the 27th November, 1851, the 12th December, 1853, and the 25th April, 1854, each of which are delineated on the accompanying diagram. The soundings and contour lines of each survey are shown respectively in different columns, as follows :—

The survey of the	27th November,	1850,	in	red.
" " "	27th "	1851,	in	blue.
" " "	12th December,	1853,	in	black.
" " "	20th April,	1854,	in	yellow.

An examination thereof will show very clearly the progressive advancement of the shoal northward, attributable to the same causes and formed in the same manner as already explained in the paper referred to. The diagram shows the minimum width of the channel between 10 feet water lines to be as follows at the several dates :—

1st October,	1849	108	yards.
27th November,	1850	100	"
27th November,	1851	90	"
12th December,	1853	77	"
20th April,	1854	73	"

As the north 10 feet water line of the channel is 13 yards south of the Queen's Wharf, in taking the width of the entrance from the edge of the wharf, 13 yards must be added to each of the distances. Although these figures are not a fair criterion to judge of the rate of advancement of the shoal, seeing that the precise position of the annual deposit is not always in the line of the minimum width of channel; yet these and the diagram prove very positively the progressive encroachment, and show an average narrowing of the channel of about eight yards annually, thus establishing the truth of the deductions based upon my previous survey, as stated in the accompanying paper, and illustrated by a model of the entrance deposited in the museum of the Canadian Institute.

With these measurements, taken with the utmost care, and with others similarly taken at the isthmus, we are now in a position to answer in very positive terms those questions most particularly referred to in the notice you have issued.

These propositions are as follows: "The effects which have been produced, or are likely to be produced, by the present breach at the eastern extremity of the Bay of Toronto, particularly with reference to the bar at the entrance to the bay. If prejudicial to the harbour, suggest the best means of closing it, and of strengthening that part of the peninsula against further encroachments by the waters of the lake.

First, then, the breach has no appreciable effect on the bar, for during the period when it was open the bar has been enlarged in precisely the same manner, through the same cause, and at a similar rate to that in which its formation proceeded when no breach existed.

Second.—Reasoning by analogy from the above, the breach (if again opened) will not likely produce any appreciable effect, beneficial or otherwise, on the bar.

Third.—The effects produced on the harbour generally by the breach amount only to an unimportant change in the contour lines under 15 feet water in its immediate vicinity, and there only; which change, when viewed in relation to the harbour as a whole, can not be considered of any moment whatever; whilst, however, it has hitherto been prejudicial to an almost inappreciable extent, and although now completely closed by the westward progressive motion of the beach, it is undoubtedly subject to be opened again by the same causes which formerly produced it, viz.: the destructive action of storms point blank on the shore, and may, by a continuance thereof, be dangerously enlarged. It is, therefore, desirable that a recurrence of this breach should be guarded against, and I proceed to submit how, in my opinion, this may be effected.

To strengthen this part of the peninsula two methods present themselves: 1st, the construction of groynes; 2nd, the construction of a canal or eastern entrance. Two properly constructed groynes, established on the lines marked in red, on plan No. 2, would effectually and permanently strengthen and protect this part of the peninsula, by retarding the progressive motion of the beach, and thus arresting the moving sand and gravel, an accumulation would gradually be formed on the outer shore calculated to prevent further encroachments of the lake.

The construction of a canal at the isthmus is a proposition on which, along with the breach, there has been great diversity of opinion, as will be seen from the following extracts from reports on the subject, recently published:—

Mr. Shanly says, 28th January, 1852: "The very great advantage to be derived from having an eastern entrance to the lake will probably keep this subject so constantly before the public that the experiment will ere long be tried, more especially as the breach which has lately occured would seem to have taken the initiative in the matter and 'pointed out the way.'

"The making of such a channel will be a simple matter of cost, and once made, a short time will serve to show whether the advantages accruing from it will be sufficient to counterbalance the expense of maintaining it. I have termed it an experiment, and such I believe it to be in the widest acceptation of the term—being doubtful that the problem of what its effect upon the harbour will be can be satisfactorily solved beforehand. It may prove immensely detrimental to the bay, in drifting in vast quantities of silt and

shingle ; or it may simply fail to accomplish the end intended by working out its own destruction by silting up more rapidly than the dredge could free it. None, I think, will deny that one or other of these results is amongst the possible contingencies waiting on the experiment in question, and, though I have not given the matter the attention necessary to enable me to pronounce confidently on the above points, I must record my opinion that the new channel would not be a self sustaining one, and that its effect upon the present entrance would be the reverse of beneficial."

Mr. Kivas Tully says, 10th February, 1853 : "I would now direct attention to the eastern entrance, which has been lately formed, and which I venture to predict, will not be closed again." And further, he says, "The breach which has been made lately at that portion of the peninsula called the Narrows, about half a mile east of Privat's tavern, shows the practicability of constructing an eastern entrance, and it is not likely that this new channel will ever be filled up from natural causes.

"I examined this channel on the 8th inst. It is about fifty yards wide and three feet in depth, with a current of about two miles an hour running through it in a south-easterly direction. The wind blowing strong at the time from the south-south-west, the current was quite sufficient to keep the channel clear of the sand which was washing into the entrance with the return of the waves, which were pretty high at the time. At all times there will be a current through this channel, either into or out of the harbour. During the prevalence of an easterly gale the current will be inwards at the eastern, and outwards at the western entrance ; and during a westerly gale this action will be reversed, and the velocity of these currents will be sufficient to keep both entrances open."

Captain Richardson says, January, 1854 : "The boundaries of the harbour being of sand, unless known physical laws be suspended for the benefit of Toronto Harbour, a current through it will accelerate its ruin. I will here simply state my opinion on the effect that a canal 200 feet wide and twelve feet deep at the Narrows would have upon the harbour. During a strong south-west wind it would cause such a current over the bar and along the south side of it (judging from the effects as now seen at the breach) as not only to deluge the harbour with sand, but in a short time to sweep away Block-house Point and all the inequalities of the north side of the peninsula, and convert the harbour into a wide mouthed bay, at the expense of the east end of it first. With the peninsula intact, all gales are favourable to the channel and maintenance of the bar. During a breach in the peninsula all high winds are more or less destructive to the harbour." "The present breach by the lake at the Narrows is similar to the warning shock of an earthquake before volcanic eruption—it forebodes coming events—and an irruption of sand into the harbour, during some extraordinary gale, may be found as destructive to it as an irruption of lava to vineyards and villages."

I am inclined to agree with Mr. Shanly in considering the effects of an eastern entrance somewhat problematical, whilst I am induced to believe that both the opinions above quoted are based on very insufficient grounds, as on the one hand the breach has been already closed without artificial aid, and on the other its effects have not fulfilled the predictions. As a proof also that by far too much stress has been placed on the effects of lake currents, the breach is now filled to such an extent with sand that without a previous knowledge of its position one could hardly tell where it had existed.

That currents exist at the present entrance there is no doubt, and, whether attributable to the wind or other natural causes, these currents are doubtless due to occasional differences of level between the waters in the bay and the open lake. If a particular wind exerts a force sufficient to elevate the lake in the vicinity of Toronto a certain number of inches, that rise must of necessity be communicated to the bay through the entrance, and hence a current of a certain velocity ; and this operation would be reversed on the falling of the water in the lake by a change or fall of the wind. If, therefore, the harbour be provided with two entrances, and if we assume, for the sake of argument, that the sectional area of the second entrance be equal to the first, the current in this case will be equally divided, and its effects, whatever they may be, diminished one-half, and so in proportion to the relative sectional area of the entrances. Thus, then, the effects of currents at the western

entrance will be diminished in porportion to the width and depth of the proposed canal at the isthmus.

We now arrive at the question: What are those effects? The undoubted tendency of currents in a channel such as the entrance to Toronto Harbour is to increase its width and depth; it does not follow that currents in this case have no such tendency because neither width nor depth have been increased, since they may have been exerted in counteracting other causes as powerful as themselves; but I think it will clearly follow that the currents have no effect, or at least no effect of real or practical value, if it can be shown that the channel has been narrowed in width nearly at an equal rate during equal or proportionate times, for it must be observed that the currents would necessarily increase in velocity, and hence in their scouring effects, the more the opening through which they passed was contracted. Since the end of last century up to 1849, the average rate of the encroachment of the shoal is shown to have been from 7 to 10 yards per annum. Since then, during $4\frac{1}{2}$ years it has advanced 35 yards, giving an average rate per annum of 8 yards; and during the last four months, it has advanced at the rate of nearly 12 yards per annum. Thus, then, while the width of the entrance has been diminished, the annual rate of the encroachment of the shoal has actually increased, and the deposit moreover has generally occurred at that point where the current (if it had any effect) would have been the most active. Hence no other conclusion can be come to than that there are no under currents in the channel, or if there are they have proved to be of no practical value. The fear, therefore, of destroying or diminishing the effect of the currents at the western entrance by the construction of a canal at the isthmus may be entirely laid aside, seeing that there are none.

We have now to consider whether or not the proposed canal would be self sustaining; and in this respect I am still of opinion that it would not. To place its outer entrance beyond the influence of the beach action it would be requisite to extend the piers into deep water as shown on the plan; through course of time, the progressive action being totally arrested an accumulation would gradually form, more especially on the eastern side of the canal until reaching the extremity of the piers, ultimately rounding them to the detriment of the artificial channel; to prevent which contingency the formation of additional groynes from time to time would be necessary; the construction of which, although not involving much outlay, would always be chargeable to the revenue of the canal.

I accordingly conclude that in relation to the present harbour entrance the construction of the canal would be neither beneficial nor detrimental, and that if the preservation of the bay be alone desired that object can more cheaply and quite as effectually be attained by the much more economical expedient of the groynes on the lake beach. These groynes would probably cost £750 or £1,000, whilst the canal could not be constructed for less than £45,000, and, inasmuch as the latter may not be considered an engineering necessity, it may be simply viewed in its commercial aspects. Whether the convenience be desirable for the eastern trade of the port, and if desirable, but not actually necessary, whether the work would be remunerative. Upon this latter point I entertain strong doubts, yet it is sufficient for me in the performance of my present duty to express my opinions only on the engineering question, leaving the better qualified body whom I am addressing to determine that of the commercial convenience. There exists no engineering necessity for the canal, and its construction would result in no advantage beyond that due to increased facility of communication between this port and the eastern portions of Lake Ontario.

I now proceed to reply to the next question submitted, viz: "The advisability or otherwise of enlarging the opening between the harbour and Ashbridge's Bay, or of making a permanent opening into the lake from Ashbridge's Bay." In doing so I shall consider it first in regard to engineering, and secondly in reference to commercial purposes.

Ashbridge's Bay, as commonly known, comprises an area of about 800 acres, triangular in form, with the apex eastward, half of which area may with sufficient accuracy for our present intention be taken as marsh land, the other moiety water of very various depths. It is divided from the Bay of Toronto by a narrow belting of sand and gravel

beach, through which two channels have been formed by the waters of the Don delivered into the main bay. Lakeward it is protected and separated from the main lake by a long, narrow sand beach precisely similar in formation to the neck of the peninsula, and through which the lake storms make repeated breaches. To construct proper works of protection to a beach so exposed and so treacherous, and to excavate so large an area of marsh would be a work of such immense cost as not to be justified except by the most stringent and positive necessity, and under the warranty of certain and indisputable advantages.

It has been argued that by increasing the body of water within the Bay of Toronto, *thus extended*, a strengthened scour at the entrances would result sufficient to ensure their maintenance through all time. I have already, I trust, satisfactorily proved that no scour results from the present currents, which, indeed, are entirely superficial, and I think it is undeniable that those currents are mainly created by fluctuations in the lake levels, traceable to variations in the wind and possibly to some more remote and unappreciable agencies. Now the maximum variation in the bay water levels hitherto observed, even on extraordinary occasions, during any twenty-four (24) hours (and it is clear that to extend the time would be to diminish the effect) may be taken at five inches, and would give 800,000 cubic yards of water in the whole bay due to the rise, and effective for scour, but the discharge of this quantity, as has been shown, has never retarded the formation of the bar. Excavate Ashbridge's Bay, combine it with the present harbour, and we should obtain at times of similar variations of level 530,000 cubic yards of water additional, or an increase of 66 per cent. on the quantity of water now occasionally flowing through the channel. And this addition can only affect the duration of the current, not its velocity, since the vertical column of water is not increased thereby, and hence also the velocity is not. Moreover, I am inclined to think we have taken much too favourable a view of the question in assuming a rise of five inches; I have done so in the absence of more correct knowledge regarding phenomena of which so little, indeed, I may say nothing authentic of value is known (for this purpose the self acting tide guage referred to was intended). Although in possession of daily and occasionally more frequent observations reduced to a common datum, the information conveyed thereby is quite insufficient on which to venture an assertion, yet from the evidence before me, I doubt much if the daily fluctuations exceed one-fourth the amount above stated throughout the year. It is not reasonable, in view of the utter insufficiency of the present currents, to anticipate that this addition in duration only would yield an effective scour, and, accordingly, I conclude that with such an object the combination of Ashbridge's with the Toronto Bay would be valueless.

Again, it has been suggested that by such a combination, together with an opening or canal to the extreme eastward, a constant current would be insured through the entire bay, and thus the channel kept open by efficient scour. Such an opinion would seem to be based on erroneous observation. The currents, still always due and identical with the variations of lake levels, would still be superficial, and so long as those variations continue to be (and they always will be) unimportant in amount and gradual both in regard to volume and time—so long, I believe, will all efforts fail to secure an efficient scour.

I do not, therefore, think it necessary or expedient in an engineering view to effect this combination, or to unite these bays even by the enlargement of the present channel. If the present breach of the Toronto Bay be such as to require protective works, how much more would they be necessary where the existing beach of Ashbridge's Bay is weak and treacherous, and extended in a tenfold degree. And, moreover, if a channel only were constructed, imminent danger would result from the contact of so large an area of swamped land, unless the channel were in fact constructed throughout the length of the marsh as a canal. It might be expedient to direct the water of the Don permanently into Ashbridge's Bay, not, indeed, that the deposit from that river is so extensive as to be much feared, for the chart shows that the deposition is of slow growth and far less than is popularly imagined, but that, as those waters are of no value to the main harbour and might be made an effective conduit for the sewage of the city, the diversion would, with such an object, be conducive to the health of the city, whilst not in a degree detrimental to its harbour.

If then I am correct in asserting that no advantage would result in an engineering point of view by the opening of Ashbridge's Bay, it only remains to be considered whether when regarded commercially it is a desirable work, and I confess that when contemplating the extent of the present harbour, and the construction of the Esplanade by which shipping accommodation may so largely be extended, I can discover no necessity by which to justify so costly, and I fear so doubtful if not dangerous an experiment.

Having thus expressed my opinion on all the points submitted in your advertisement, I shall now take leave to direct your attention to another, and in my opinion, the most important of all the questions relating to the efficient preservation of this harbour. Until a comparatively recent period the formation to which this bay is due was entirely consistent with the most admirable provisions of harbour capacity, shelter, anchorage, and the conveniences of navigation. Up to such a period (and it is demonstrated by the charts) Nature was engaged in work eminently useful, and in a manner most fortunate and unimpeachable; nor did our predecessors fail to discover how excellent a haven had been formed, as to its inducements may be traced the selection of the site for the city, just as surely as to its influence may be attributed the rapid growth and great prosperity of this metropolis. At that time, and it may be taken as A.D. 1800, Nature began to destroy that which she had herself so well completed, and recently by such palpable encroachments on the entrance to the bay as naturally to induce alarm lest its commercial value might be endangered.

I have already shown how regularly and constantly this encroachment has been proceeding—how, year after year, the channel has been decreasing in width and the shoal extending, and I have endeavored to trace the source and causes to which these dangerous accumulations are to be attributed, showing, I trust satisfactorily, that the same agencies are engaged to this day in the same work of injury.

And yet it is strange that with the exception of the construction of the Queen's Wharf in 1835 and its extension in 1853, works in my opinion entirely inconsistent with, and, as the event has proved, entirely inadequate to the object sought, no effort has been directed to the preservation of the present harbour channel, but public attention has been attracted by speculative and ambitious attempts to alter where alteration is unnecessary and dangerous, and to do that which Nature has left perfect to our hands; neglecting meanwhile the one and only point in which her operations may be regretted, and where interference is justified by danger. It is to this point that I shall now address myself, convinced that if this be neglected, works at no other place can compensate for the omission, or preserve the harbour in an efficient state.

In the Harbour Master's report of January last he says: "Upon the faith of the current (to which in a preceding paragraph he declares that the harbour owes its navigation) the extension of the Queen's Wharf was advised, and although it is as yet only constructed half its length, a widening in the channel has already taken place." I have already proved (by demonstration of actual measurement) that the currents here are too feeble to be of any service in retarding or removing the deposit, and the declaration of the Harbour Master appears to be inconsistent with the facts. This is scarcely extraordinary, for, unless the measurements be made with the greatest delicacy and reduced to a well established datum, it is difficult, nay impossible, owing to the frequent variations in level, to arrive at accuracy.

From recent measurements made by me in continuance of the whole system of survey upon which the charts have been laid down, it appears indisputable that since the extension of the Queen's wharf was brought to its present state, and in the space of 128 days the ten feet water line of the shoal has been projected fifteen feet, the eight feet line twelve feet, and the six feet line twenty-five feet into the channel northerly, thus diminishing its widths by those amounts. It is accordingly apparent that the Queen's Wharf works, recent as well as remote, although fortuitously now of eminent advantage in a commercial point of view, have failed in the engineering service for which they were advised, and they have failed because they have *not* resulted in strengthening the current, and in creating a scour, as was anticipated, because, in truth, the current, which has ever been inoperative in checking the shoal formation, is so still, being now as always superficial.

In the paper to which I have so frequently referred I have demonstrated the manner in which this encroachment is proceeding, and it is sufficient here to repeat that it is brought from the southward, and that every effort to check it by the current has been ineffectual. We may, therefore, reasonably abandon such an expedient, which, however excellent and efficient it may be found in tidal waters, should not, therefore, induce us to rely upon its adequacy when attempted under such totally different circumstances.

To preserve the entrance from further encroachments of the shoal, and to arrest the beach drift at a convenient and safe distance therefrom, I would recommend the early construction of the following works :—

1st. A groyne at the Lighthouse Point to retard the sand now moving northerly, and divert it into deep water westerly.

2nd. An auxilliary groyne opposite Gibraltar Point, to arrest and counteract all progressive action along the west side of the shoal, thus enabling all drift to accumulate south of the clear water opening of the bay, and preserving the present extended passages to facilitate the early removal of ice in the spring.

3rd. A pier along the south edge of the channel, as shown on the plan, of a total length of 290 yards, cutting off about 350 feet from the point of the shoal to a depth of twelve or fourteen feet by dredging, thus enlarging and permanently deepening the navigable entrance from 240 as now to 600 feet as proposed. With such work properly constructed, I am confident in the opinion that the difficulties hitherto connected with the western channel would be removed and that the entrance to the bay would be permanently preserved in an efficient condition. The harbour would then, for extent and convenience, be I believe altogether sufficient and satisfactory. And I take leave very respectfully to repeat my conviction that it is more consistent with prudence to content ourselves by checking an ascertained evil, by simple, palpable, and safe expedients, than to rush wildly into costly experiments having no actual bearing on, and at a distance from, the only evil by which we are embarrassed in the frail hope of begetting an advantage of uncertain value.

The following is an approximate estimate of the several works proposed : —

1st.	A groyne at Lighthouse Point 450 feet in length.....	£ 900
2nd.	A groyne near Gibraltar Point 800 feet in length.....	600
3rd.	A pier at the entrance, estimated 14 feet under water, and 55,000 cubic yards dredging.....	10,200
4th.	Two groynes at the isthmus.....	850
		£12,550

It will be observed that a large item in the above estimate is involved by the proposed enlargement of the present entrance to a full width of 600 feet of deep water ; that, although 400 feet might suffice and reduce the first cost about three thousand pounds, yet the increase and permanent advantages resulting from the enlarged entrance would, I am inclined to think, warrant the additional expenditure. Since you do not at present require detailed plans and estimates of the proposed works I have deemed it unnecessary to prepare them. I may, however, again refer to the fact that I have in my possession charts and other documents bearing upon the question before you, and although they are the basis upon which the opinion now submitted has been formed, as they have been prepared at great labour and expense, and are of some value to me, I have refrained from attaching them to this Report.

If, however, you desire to examine them, I shall be most happy to attend at any appointed time, and submit them to your inspection.

I have the honour to be, Sir,

Your obedient servant,

SANDFORD FLEMING.

Toronto, May 4th, 1854.

(The Canadian Journal, 1855, Vol. III, App.)

REPORT

On the Means to be Adopted for the Preservation and Improvement of the Harbour of Toronto, by Kivas Tully, Esq., Provincial Surveyor.

(The Third Premium of Fifty Pounds was Awarded to the Author of this Report.)

The opinions of the several professional and scientific persons who have previously written on this subject are so widely different, that to discuss each separately would far exceed the limits of a report of this description, and which, for all practical purposes, cannot be considered necessary. The present intention, therefore, is to condense the subject as much as possible, consistent with a due explanation of the means to be recommended, founded on the most reliable data.

It is proposed to divide the Report into two heads, one on the Preservation, the other on the Improvement of the Harbour; the expense necessary for preserving the harbour, as will be shown, being far less than that which may be required for its improvement.

Previous to entering on the discussion of the subject, it is necessary to remark that the construction and extension of the Queen's Wharf was the most advisable course that could be followed heretofore, both for the preservation as well as the improvement of the harbour, and must be a source of much satisfaction to those who recommended its construction originally, and were afterwards instrumental in carrying the project out—to think that, up to the present time, there has been no useless expenditure, a result that cannot always be avoided even by the most experienced persons.

1st. The preservation of the harbour.

In order to form a correct opinion it is necessary to inquire into the causes of the original formation and increase of the peninsula forming its southern boundary.

Sir Richard Bonnycastle, in his Report in 1834, in reference to this subject, states : —

"The peninsula opposite the southern face of the City of Toronto appears to me a *much more ancient formation than is generally imagined;* it is composed of sand in various states of cohesion, the surface being usually disintegrated, and increasing only in firmness and tenacity as it increases in depth. It is probably one of the many ridges of the bottom of the vast lake which existed before the present Ontario and Erie were formed out of its drainage, nor was the shape of the peninsula materially altered for a vast length of time.

"The French entered the basin and fancied it a river when they first explored the country, under the guidance of Hennepin, and the oldest surveys show little or no difference in its outline.

"It is not necessary, however, with the object at present in view, to enter into a geological description to prove that the peninsula was made during the sedimentary deposition of the tertiary periods; but it is useful to that purpose to ascertain that it is not comparatively new, or in the constant habit of receiving great accessories to its bulk and extension."

These opinions, written twenty years ago, besides being corroborated by later authorities, have been proved to be correct by recent examination.

A superior set of boring irons was constructed for the purpose of ascertaining the substratum of the peninsula, and in order to set the question forever at rest.

The first and second trials were made at Gibraltar Point, and the same result was obtained in both instances, namely, sand and gravel in alternate layers three feet in depth from the surface of the water, and finding, after considerable labour, with four persons

working the boring irons, that no greater depth than three feet could be obtained, a specimen of the substratum was procured with the shell auger, and found to be blue clay, or hard pan, as it is more commonly called.

The resistance of the sand and gravel on the third trial, at the Narrows, east of Privat's tavern, was found to be so great after boring about two feet that a lighter boring iron was procured, with one end hollowed out to receive the substratum, and, after several trials between Gibraltar Point and the Narrows along the centre of the peninsula, the same result was obtained. Specimens of the clay and a memorandum of their respective positions and depths are herewith submitted for inspection. The hollow in the iron being of small capacity a small portion of the clay could only be procured, and even this is mixed with the fine sand which lies on the surface of the clay.

There is, however, sufficient evidence of clay in the several specimens to prove the assertion that the base of the peninsula is co-eval with that of the mainland, and not a deposit caused by the action of the waters of Lake Ontario.

It is intended to pursue the investigation still further, and, in all probability, the same result will be found on boring east of the Narrows,towards the Heights of Scarborough, and also on the neck of land that separates the harbour from Ashbridge's Bay.

Whether a portion of the sand and gravel resting on the substratum of the peninsula was an original formation or not it would be difficult to ascertain, but the most likely conclusion would be that it has been deposited on the ridge forming the base of the peninsula since the period when the water which covered the greater portion of the North American Continent subsided to its present level.

The sources from which this deposit is and has been supplied, is explained in a letter of mine, dated February 10th, 1853, as follows: "The continued accumulation of deposit on the peninsula are the washing away of the shores of the lake to the east and west of Toronto. During an easterly gale, which generally lasts three days, the *debris* from the Scarborough Heights is washed along the shore of the peninsula to the lee of the Lighthouse Point, and during westerly gales, which generally succeed easterly ones, the *debris* from the shore west of Toronto as far as the point of the Humber Bay is washed along the shore towards the peninsula, and meeting the current of the Don at the western entrance is deposited on the bar."

A comparison between the deposit on the peninsula and the formation of the Scarborough Heights will prove that not one twentieth part of the *debris* finds its way to the peninsula.

The formation of the Scarborough Heights being principally argillaceous, and the deposit on the peninsula being granitic *detritus*, the argillaceous portion of the *debris* being the lightest is carried to a much greater distance, and sometimes three or four miles out into the lake, by the undertow, where it is deposited when the causes that originally removed it cease.

Pursuing this question still further, it will be found on examination, that a considerable portion of the *debris* travels eastward as well as westward, the prevailing winds being westerly, though the easterly winds are the most violent. The effect produced by the prevailing westerly winds in Lake Erie is evidenced by the more extended deposit forming Long Point, and also the Harbour of Erie.

The above remarks, though more diffuse than may be considered requisite, are introduced to prove that the whole of the *debris* from the Scarborough Heights is not deposited on the peninsula, and the same may be said of the deposits from the river Don.

That the construction of the Queen's Wharf has had the effect of changing the line of deposit on the bar cannot be for one moment doubted.

By referring to the map published by Mr. Bouchette, in 1815, it will be observed that the point of the bar was more easterly than it is at the present time, and to the increased back current out of the harbour, caused by the contraction of the channel, may principally be attributed this result.

Assuming the above remarks to be admitted facts, as such they cannot be controverted by mere conjectures—some of which are calculated to remind a person of the reply of a celebrated member of the British Parliament to the speech of a consequential representative from one of the inland counties, who felt flattered at being noticed by him: "There is a great deal in the hon. member's speech that is new and true, but, unfortunately,

what is true is not new, and what is new is not true ;" and with these remarks he went on with the subject under debate.

Whatever may have been the result of the action of the current of the River Don on the formation of the peninsula, it has not much influence at the present time—the current being very trifling at ordinary times. During floods the injury to the harbour by the deposits of alluvial matter suspended in its waters is very considerable, though, fortunately, the direction of the flood when the Don overflows its banks is into Ashbridge's Bay, where the greatest amount of deposit is made. A large portion, however, reaches the harbour, and the lighter particles are even carried out some miles into the lake before they are deposited. During the prevalence of a flood in the Niagara River, about five years ago, caused by continued wet weather when the ice was breaking up in Lake Erie, the water at the mouth of the river for five miles at least from the shore, and an equal distance on either side, was quite discoloured, and the neutral line between the lake and the river waters was quite distinct.

If the foregoing remarks are correct, and there can be no reason to doubt them, it must be admitted that the injury to the harbour in consequence of this deposit is greater than the benefit to be derived from its current. As one of the precautions necessary for the preservation of the harbour, it is advisable to alter the direction of the current into Ashbridge's Bay, and allow it to find a passage into the lake through the eastern entrance in Ashbridge's Bay, and if at any future period a canal should be made connecting Ashbridge's Bay and the harbour, the entrance into the harbour should be protected by gates, so as to prevent the current from the east bringing with it the mud that has been deposited in the marsh for ages past, the mud in Ashbridge's Bay being at least twenty feet higher than the bottom of the harbour.

Fortunately, the present connection between the bay and the harbour is very slight, and, according to the annexed estimate, a comparatively small amount would be necessary to close up the mouths of the Don, and alter the direction of the current into Ashbridge's Bay.

The deposit from the sewers of the city in the harbour is much more considerable than would at first be supposed ; from experience in the construction of wharves, piling, etc., it has been found that, from Yonge Street on the west to the Don on the east, the average depth of deposit from the sewers alone is not less than two feet ; taking the distance to be 5,000 feet, with an average breadth of at least 300 feet, we have a quantity equal to about 100,000 cubic yards, a very serious amount, considering that it only extends over a period of say twenty years ; the annual deposit will of course increase in proportion to the population, so that at the end of twenty years more, taking the population at that time to be 100,000, the increase of deposit may be fairly calculated to be at least 700,000 cubic yards in addition.

In Sir R. Bonnycastle's Report, this subject is also briefly alluded to as follows, and the injury to the harbour anticipated : "I also beg to remark that in making the sewers for this city it would be very advisable to construct one main sewer through the whole length down to the marsh, instead of lateral ones into the bay."

The difficulty of constructing a main sewer in an easterly direction is insurmountable, in consequence of the want of a sufficient fall ; a sewer constructed as above described being almost on a level, would be always subject to be choked up with the deposits from the lateral drains, and from this inevitable result would be destroyed in a few years.

In a letter of mine addressed to the City Council, in 1853, it is recommended "that a covered channel should be constructed in the centre and beneath the intended Esplanade, from the River Don to Queen's Wharf."

"The drains of the city to be extended to this channel, and a portion of the current of the River Don to be turned into it by damming the present channel and allowing the surplus water to flow into the marsh, as at present, over a wast weir one foot in height above the present level of the water." This would be self acting, and would carry off the unhealthy deposits which are now being made in the harbour, as evidenced by the rank vegetable growth in the stagnant water about the wharves.

As the final disposition of this matter rests with the City Council, it may be considered sufficient for the present purpose to state that for the preservation of the harbour the sewers should not be permitted any longer to empty their filth into it, which, if other-

wise provided for, instead of being an injury to the harbour and a cause of unhealthiness to the citizens, would eventually be a source of profit.

For the preservation of the harbour the next question that suggests itself is the strengthening, or the opening, of that portion of the peninsula termed the Narrows; when the question of the improvement of the harbour is taken up, it will be sufficient then to show the advantage to be derived from the construction of an eastern entrance, or the contrary; but as far as regards the preservation of the harbour is concerned, there can be no doubt that the strengthening, and not the opening, of this portion of the bay is the safest and the most advisable plan.

Considerable damage has already been done by allowing the breach at the Narrows to remain open so long as it has been, as some thousands of cubic yards of sand have been washed into the harbour during the high water and the action of easterly gales.

Very little damage can be done to the harbour at present at this point, as the prevalence of westerly gales in the autumn of last year, and the formidable barrier of ice that protected it during the winter collected a considerable deposit on the lake side, and since that time, the water having fallen about 15 inches, has increased the width of this portion of the peninsula considerably, but from its position being a curve from the regular line of the beach it will always be subject to damage during high water, as the whole force of the waves produced by an easterly storm breaks on it and carries the lighter particles of sand into the harbour.

To strengthen it and encourage the accumulation of sand at this point two rows of piles 20 feet apart and 5 feet above the surface should be driven on the inner or harbour side from the marsh to Privat's tavern, the piles to be lined with plank on the inside, and the space filled up with the deposit from the marsh, which is convenient; the base of a substantial bank will thus be formed, which can still further be strengthened by planting, etc.; the action of both wind and water on the sand will be to form a slope on the lake side which will most effectually secure this portion of the peninsula from further encroachment. The cost of the above is also stated in the annexed estimate.

The construction and extension of the Queen's Wharf having determined the result at the western entrance as before stated, the old adage, "let well enough alone," may be safely applied in this instance.

If 100 feet is dredged from the point of the bar so as to widen the channel to 400 feet, to enable sailing vessels to beat into the harbour during easterly winds, as they were in the habit of doing until the present, and the wharf extended westerly in a line with the point of the bar, which work is now under contract and will be completed this year, the bar cannot possibly close up the channel, as the current into and out of the harbour will always be sufficient to keep the channel clear; the opinion which was expressed in my letter of 1853, experience has proved to be correct, as the extension of the Queen's Wharf 200 feet since that time has produced the very result which was then anticipated.

It is there stated, "as to the extension of the Queen's Wharf westward it cannot affect the channel, provided the deposit on the bar is removed as recommended; it would not increase the deposit, it would merely alter its form, which would then assume a westerly direction."

In order to understand the subject thoroughly it will be necessary to investigate the effects of the current into and out of the harbour during the prevalence of easterly as well as westerly gales. As to the fluctuations of the water in the lake during calm weather, they are so irregular in their action that the result is inappreciable, though certainly beneficial.

During a westerly gale the water rising suddenly in the lake by the action of the wind, the surface level will of course be maintained, and the water will flow into the harbour. The effect of the force of the wind on the surface level of the water, causing it to rise at the opposite point from which the wind may be blowing at the time, was ascertained by Smeaton to be eight inches in one mile, the wind blowing a strong gale, or at the rate of forty miles per hour, at the time. The experiment, having been made on the water in a narrow canal, is hardly any criterion of the effects that a gale of wind of the same velocity might have on so large an expanse of water as Lake Ontario, but still it will afford some data to be enabled to judge of its effects by comparison.

The great damage caused occasionally at the harbour of Buffalo and other ports on Lake Erie by the sudden rise of water, caused by severe westerly gales in that comparatively shallow lake, is also a further proof of the force that is produced by the action of the wind on a large surface of water. The actual effect can only be ascertained by continued observation. The records kept during the last few years by the harbour master prove the sudden rise of the water from the effect of an easterly as well as westerly gale to be from four to six inches, and even more.

The above remarks refer to the first effect; for the flow of water into the bay through the western entrance the reaction has also to be considered, and according to the laws of motion, which are applicable to fluids as well as solids, the action and reaction are equal; the action is constant in its effects when the water in the harbour is raised to the same level as the water in the lake, a reaction takes place, and two currents are established, one into and the other out of the harbour, and those currents are much increased by the surf on the bar, which, acting as a sunken breakwater, the surface water is forced into the harbour by its momentum and returns by the deep channel near the wharf. To the effect of this current may be attributed the steep edge on the inside of the bar, and it has also been found efficacious in scouring the channel.

The effect produced by an easterly gale is the same, with the exception that, as the waves do not break with such great violence on the bar, the additional effect from this cause is lost.

The difference of level caused by an easterly gale is greater than that produced by a westerly one, as it acts on a larger surface of water.

As an easterly gale increases the deposit on the bar on the lake side more than a westerly one, it is evident that a westerly gale is more beneficial in its effects on the maintenance of the channel.

From the above remarks the conclusion may fairly be drawn that a channel which has been maintained by natural causes for years past may be injured by an interference with those causes which the construction of a pier on the point of the bar, parallel to the Queen's Wharf, would most decidedly produce.

The recapitulation of the several recommendations for the preservation of the harbour will therefore be as follows :—

1st. The closing of the Don, and diverting the current into Ashbridge's Bay.
2nd. The sewage of the city to be prevented from being emptied into the harbour.
3rd. The strengthening of the narrows of the peninsula.
4th. The continued extension of the Queen's Wharf, so as to be always on a line with the point of the bar.

That the harbour can be preserved for ages by the course above recommended, I have not the least doubt, and should such a contingency ever arise as the removal of the deposit on the base of the peninsula by any future action of the waters of the lake, which is extremely doubtful, the recent examinations by boring prove that the substratum is sufficient to bear a stone facing on the lake side, similar to the one constructed in front of the new garrison, which has stood the test of six years' experience without any injurious effect, and to resist the action of the waters of the lake for an indefinite period, so that as far as the decay of the peninsula is concerned it is altogether mythical, and reduces the question to one of expense.

THE IMPROVEMENT OF THE HARBOUR.

With respect to the improvement of the harbour, it is intended to treat this question altogether as a separate matter.

The only alterations from the preceding remarks on the preservation of the harbour would be, instead of strengthening the peninsula at the Narrows, the opening is recommended.

The disposition of the River Don, the sewage of the city, and the maintenance of the western channel would remain the same; the question, therefore, to be considered will be, the practicability of constructing an eastern entrance, its maintenance, and the effect produced on the western entrance in consequence of its construction.

The engineering difficulties to be encountered in the construction of an eastern entrance will be considerable, and attended with much greater expense than at first would be imagined.

The base of the peninsula having been ascertained to be of blue clay, or hard pan as it is commonly called, and being five feet from the present surface of the water at this point, the difficulties are rather increased than diminished, though the work when completed would be more substantial than if it was altogether sand.

The only way in which the blue clay or hard pan can be excavated to a depth so as to afford twelve feet at low water would be by the construction of coffer dams instead of dredging, which could be resorted to if sand and gravel alone had to be excavacated.

The foundation of the piers would, however, be more secure and less liable to injury from the effects of the heavy sea that will have to be encountered than if sand and gravel formed the foundation.

Accompanying this Report is a map copied from one in the possession of the City Council, which explains the position and capacity of the proposed eastern entrance.

In order to prevent the *debris* from the Scarborough Heights from being conveyed into the harbour by the current which will be caused by an easterly gale, it would be necessary to run the piers into 20 feet of water, at least, or to the line where the waves break, which indicates the state of the under currrent; to carry this out successfully will require the piers on either side to average 3,000 feet each, the eastern pier to project 500 feet further than the other, so as to afford sufficient shelter to vessels during moderate gales in running into the harbour.

For reasons that will hereafter be evident, it would not be advisable to make the entrance wider than 200 feet.

The piers would require at least to be 40 feet wide, and loaded with stone in the same manner as the extension now in course of construction at the Queen's Wharf.

By constructing the piers as proposed it is considered they will be sufficiently strong to resist the effect of the most severe easterly storms, and the piers being run out into 20 feet of water, beyond the extent of the under current, no substance further than the lighter particles of argillaceous matter, which are held in suspension by the agitated water, can enter the harbour ; and in case of a current being established through the harbour, which would occur in an easterly storm, this suspended matter would not be deposited in the harbour, but would be carried with the current through the western channel into the lake again, and *vice versa* in case of westerly gales—in fact, it would not be more injurious than at the present time.

If this is correct, the maintenance of the eastern channel cannot be questioned ; the effect that would be produced on the western channel requires more serious consideration from the fact that the back current at the western channel would be lessened in the exact proportion as the current through the eastern, and this remark applies whether an easterly or westerly gale prevails.

The data to decide the question are as follows : The sectional area of the western channel, including the water on the bar, is, in superficial feet, 21,350 ; the sectional area of the eastern channel, 200 feet wide by 12 feet in depth, would be 2,400 ; still leaving a surplus in favour of the western channel of 18,950. By reducing these amounts to the

lowest fraction, the proportion of the sectional area of the eastern channel to that of the western would be, as nearly as possible, one-ninth.

From the above calculations it may be inferred that during an easterly or westerly gale there would still be a current flowing out of the harbour at the western channel. In an easterly gale there would be a current from the east to west through the eastern entrance, and *vice versa ;* in either case the current into or out of the harbour through the western channel, would be diminished one-ninth, and the consequent scouring effect on the western channel would be lost in this proportion. Whether this would have the effect of destroying the balance which has been maintained for so long a period is a matter of opinion.

Supposing that the point of the bar advanced eight feet per year across the channel, which however it does not, the encroachment would be nine feet instead of eight feet. When the present contract for the extension of the wharf westward 400 feet is completed, I am of opinion that the back current will be sufficient to scour the increased channel 400 feet wide, even in the event of an eastern entrance being constructed.

The current through the western channel, caused by the displacement of the water by steamers passing at full speed, is very considerable for the time it lasts, and has a good scouring effect, tending to prevent the encroachment of the bar on the channel. If an eastern entrance is constructed a portion of this effect will, of course, be lost ; the proportion in this instance it would be difficult to ascertain. I do not, however, think that the loss would be so great in any case as to endanger the filling up of the western entrance.

With regard to the arrest of the deposit on the bar by the construction of piers or groynes along the shores of the peninsula, it can only be considered as temporary, and, to be effectual, would have to be renewed and kept in repair year by year, an expense which will be found as much, if not greater than using the dredge.

In Sir Charles Lyell's Principles of Geology, page 318, speaking of the encroachments on the south coast of England, it is stated—

" It appears, from the observations of Mr. Palmer and others, that if a pier or groyne be erected anywhere on our southern or south-eastern coast to stop the progress of the beach a heap of shingle soon collects on the western side of such artificial barriers. The pebbles continue to accumulate till they rise as high as the pier or groyne, after which they pour over in great numbers during heavy gales."

According to the old saying, " Prevention is better than cure," if the the true remedy requires to be pointed out, and admitting that the continued deposit on the peninsula is caused by the *debris* from the Scarborough Heights, expend the money that would be wasted in the construction of piers or groynes in the protection of the base of the Scarborough Heights, and the object is attained; but the wisdom of this course is to be doubted ; the deposit from this source is not so great as is imagined, and it must be borne in mind that a considerable portion of the deposit on the peninsula is removed by the under current, not to be replaced except by this very supply from the Scarborough Heights, which is considered so great a nuisance. Taking all matters into consideration this supply, on the contrary, will on reflection be considered advantageous in preserving the peninsula, and consequently preserving the harbour. As to "making a permanent opening into the lake from Ashbridge's Bay," it is a question that can well be postponed, as the present opening is quite sufficient for the requirements of that portion of the harbour ; and in all future speculations on the subject it would be advisable to view it as likely to form a separate harbour altogether from the present one, as such, with an entrance into Toronto Harbour duly protected with gates to keep the mud which has collected there for ages from destroying Toronto Harbour, an excellent harbour may be constructed by running out piers into deep water, as recommended for the eastern entrance of Toronto Harbour ; the cost of such work is stated in the general estimate, though the expense is not advisable, as all available funds will be found little enough for preserving and maintaining a harbour which, up to the present time, stands unrivalled on the great lakes of this continent.

KIVAS TULLY,

Civil Engineer.

Toronto, May 3rd, 1854.

ESTIMATES

FOR THE PRESERVATION OF THE HARBOUR.

1st. Closing the River Don, and diverting the current into Ashbridge's Bay	£7,500 0 0
2nd. The strengthening of the Narrows of the peninsula...	2,500 0 0
	£10,000 0 0

FOR THE IMPROVEMENT OF THE HARBOUR.

1st. Closing the River Don	£7,500 0 0
2nd. Constructing the eastern entrance, 200 feet wide and 12 feet in depth, piers 40 feet wide, running into 20 feet of water	60,000 0 0
	£67,500 0 0

IMPROVING ASHBRIDGE'S BAY.

1st. Constructing channel in eastern end of Ashbridge's Bay, with piers, etc	£50,000 0 0
3nd. Constructing canal, with gates, etc., 60 feet wide, 10 feet of water, where shown on the map	10,000 0 0
	£60,000 0 0

KIVAS TULLY,
Civil Engineer.

Toronto, May 3rd, 1854.

(The Canadian Journal, 1855, Vol. III, App.)

REPORT

On the Preservation and Improvement of Toronto Harbour, by Hugh Richardson, Esquire, Harbour Master, Toronto.

(A Supplementary Premium of Seventy-five Pounds was awarded to the Author of this Report.)

To The Commissioners of Toronto Harbour :—

Gentlemen,—Not with any pretension to engineering, not with the presumption of competing with scientific men in plans, and estimates of plans, for the improvement of the harbour, but if I have understood the advertisement right, it admits the opinions of observers and of practical men, as well nautical as scientific, to compete in a sort of essay on the subjects embraced therein, which may lead to some beneficial decision or induce more scientific aid.

If projects are in agitation, which, if carried into effect, I think would be destructive to the harbour, nautically of little value, and commercially onerous, I, as a nautical man, a practical man and an attentive observer of the harbour of long standing, am entitled to intrude an opinion, and compete in the race of competitors, the labours of whom tend to the public benefit.

In my Report to the Commissioners of Toronto Harbour last year, I stated as my opinion that the breach then open was injurious to the harbour, and urged the necessity of closing it; and so simple and trifling was the injury then, that the breach which was made on the 13th and 14th January last, closed by the operation of nature on the 17th February following, and had the harbour belonged to myself (with the opinion I held of its injurious tendency), I should then have raised the beach with the material around me to a height above the reach of the wave. If the aspect of the breach now is in any way formidable, the delay in closing it must be attributed to the public divided opinion as to its beneficial or prejudicial effect upon the harbour. But the mass of material that has been removed from the beach, essentially altering its feature, and the drift that has been brought into the harbour, to say nothing of the undetermined effect it has had upon the bar, must convince the most skeptical of its injurious effect; and an examination of the shallow shelving coast is suffioient to preclude the idea of a natural channel ever forming there, if such an idea was ever entertained.

Further neglect may bring this harbour into the perilous and costly condition of Erie Harbour at this time, to which it has a close resemblance, where, from having allowed it to become a Presqu' Isle by a breach at the west, it is continually inundated with sand, and threatened with destruction.

The means of closing the breach when no more formidable than when I observed it last fall appear to me very simple. It can hardly have escaped the notice of the observer that whenever the height of the peninsula was above the reach of the wave, the wave was rolled back from whence it came harmless to the beach; and that it was only where the wave surmounted the apex of it that it became injurious in its descent on the opposite side.

To repair the breach in its then form, with a current through it, it required first to stop the current, which might be done with as many rough plank of 2 inches, made into cases 6 feet long by 2 feet 6 inches by 2 feet 6 inches, filled with the material of the beach, as would stretch across the narrow neck of the breach in a double row, ten or twelve feet apart, and filled in between; this would effectually stop the current (the narrow part being only sixty feet wide and far removed from the beat of the wave); the current once stopped, the process of raising the beach is the mere affair of carts and wheelbarrows, with labour and a plentiful supply of the material of the peninsula, the object of these casoons being only to stop the current, which done all would be be buried up. With moderate winds at south-west and north-east the lip of the wave would repair the beach in a fair line to a certain height almost as soon as the most active labour would raise the other part to the required height. More scientific and a more expensive process might be adopted, but none more efficient.

On examining the beach I observed the wave had never reached a height above five feet; where that height was twenty feet from the line of calm water, and treating the lake for all immediate practical purpose as at a constant level, I had only to consider the casualty of an easterly storm; then looking round me for even the lowest part of the peninsula that withstood that storm, I placed in imagination in the interval of the storm a section of it in the breach, and I felt myself secure, convinced that nothing could be so effectual in repairing the breach as the material of which it was composed.

The lake was, when I observed it last fall for the purpose of estimating the height of beach required to resist the sudden encroachment of the lake, two feet lower than the highest level, and two feet higher than the lowest. I therefore concluded that a beach six or seven feet above the highest water, at 20 feet from the line of calm water, and a hundred feet wide in all would be amply sufficient to secure the harbour against further inroad from the lake. I do not think that for many years the beach in that part has been five feet high. Be it remarked that, the water being shoal without, the wave in any storm is greatly increased in height and force in passing over the shoal water before it reaches the beach.

If cribs are made use of to stop the breach the retrocession of the peninsula (as I shall show) will in the course of time lay them bare, and even if they extended all the way to the head of Ashbridge's Bay, yet in time the whole line would be taken in reverse. Keeping the beach at all times and in all parts above the reach of the solid water of the wave, the retrocession will proceed safely, uniformly, and almost imperceptibly, but proceed it will, as it has done, and still does; breaches accelerate this, as witness the present effect, and examine the marks all the way from the fishing houses below the cross beach to some hundred yards west of Privat's Hotel.

But, until the important question of a canal at the east end of the bay is settled, I fear even the preservation of the harbour will be a secondary consideration; I shall, therefore, publicly treat this question fully in all its bearings upon public interests, that is, physically, nautically and commercially.

Physically—The superstructure of the peninsula, the southern boundary of the port, is composed of drift—that is, clean washed sand and stones; the base of it, I believe, of all the material of the cliffs of Scarborough, the substratum most probably of indurated clay. The bar or western boundary of sand and clay.

I shall not enter upon the theory of its original formation; it is sufficient for my present purpose to assume what a quarter of a century's observation bears me out in—that all the drift comes from the east, mainly the *debris* from the high lands of Scarborough, that the peninsula is the crest of a large shoal; that its maintenance above water is essential to the preservation of Toronto Harbour.

This drift is always more or less in motion by the lateral actions of the waves of the north-east and south-west winds.

Whilst the north-east wind supplies the peninsula with drift, it also by the violent action of its stormy wave erodes the beach and carries the produce gradually west. The south-west wind, more constant, but its waves less violent, brings back by a more gradual process much of this drift and mainly repairs the damage done by the former wind. But for this counteraction the peninsula would erode and be extended more rapidly west. Were the tides always one way erosion would be constant at one side of the island and accumulation on the other.

At right angles to this moving beach it is proposed to project out into deep water some eighteen hundred feet or more piers for the purpose of a navigable canal, intercepting the motion of drift both from the east and from the west.

The effect of these piers would be to cut off the supply of drift from the north-east and bring it down from the south-west, filling in the angles until it ultimately made a passage round them. But so extended would these be, and so considerable the body of water to be filled in, that bays would form both east and west, giving greater force to the wave to act upon any attenuated part of the peninsula; and it is more than probable that a very serious breach would be made in it east of the piers. The west end of the peninsula, no longer supplied, would assume another shape, bearing down from west to east and wasting away at the west.

This is the effect to be expected, presuming the piers built upon a sandy foundation and broadside on to the north-east sea (which is heavier here than at any other part of the lake) withstood its repeated concussions. It is common to allude to the piers of the Burlington Canal to support an argument in favour of the facility of erecting piers for the canal in question. The piers of the Burlington Canal are placed in the strongest possible position for piers to be, that is, end on to the only sea that can affect them, whereas those of Toronto would be placed in the weakest possible way to resist the sea—that is broadside on—and would require to be doubly massive, compared with those of the former, to stand at all.

The interior effect of a canal two hundred feet wide and twelve feet deep would be to create such a current through the harbour, with a strong south-west wind from west to east, as to bring down the sands of the bar into it, sweep those of the north margin of the peninsula down upon the canal and the east end of the bay, whilst the evil consequences of some extraordinary gale could not be calculated. I think I have seen such a hurricane upon the lake from south-west as might render both channels unnavigable for a time.

The action of the current last season, the breach open about one hundred feet wide and two and a half feet deep during a south-west gale, illustrated, upon a small scale, what would be the effect of a large opening and deep water, and amply comfirms the opinions that I publicly expressed twenty years ago, when the subject of a canal was then in agitation, that it would create such a current through the harbour, whose bar and boundaries were composed of sand, as to prejudice the existing channel.

NAUTICALLY.—The canal, if constructed, would be useless to sailing vessels in calms. With the wind off the land, it would be useless for entrance, but useful for exit to all vessels bound down the lake. With the wind at south-west and not stormy it would be valuable again for exit, but for entrance from the east every nautical man would perfer making a stretch out into the open lake, weathering the light at one long board, and rounding into the harbour with a fair wind, to hauling through the canal, coming in dead upon a lee shore, and having to beat up the bay in short tacks. With the wind at south, it could only be used for entrance; with the wind at north-east, and moderate, it would be useful to all vessels from the east, but useless to them for exit.

For steamers, to all bound inwards from the east, or outwards to the east it would be useful in moderate weather. In high winds, either north-east or south-west it could not be used.

COMMERCIALLY.—There have entered the Port of Toronto last year, by the Harbour Master's book, during the whole season for navigation, 2,433 vessels of all classes and sizes, which include the daily steamers, and 1,012 visits of wood and stone boats. Add to these 100 vessels in transit or weather bound, not reported, say 2,533 in all. Double these, upon the presumption that every vessel that comes into port goes out again, and say that 5,066 vessels in all pass the entrance of the harbour during the year. Now, taking every advantage of numbers, admit that one-half of the whole pass by canal, or 2,533 craft of every description. What toll would you put upon these vessels or cargoes to make the canal *self paying*, where the interest alone of the expenditure, at the lowest calculation, would be betwixt £3,000 and £4,000?

But take a view of it approximately to its true light, and say there are two entrances to the port—the one tolled, and the other free. The tolled canal would share the fate of a turnpiked road where there are two roads to the same place, the one a little round about, but free, the other taxed—the greater part of the traffic would go out of the way to avoid toll.

It is looking upon it in the most favourable light, to say that one-half of all the vessels entering or going out of port *could*, if they *would*, take the canal. Deducting the Niagara, the Hamilton, the Port Dalhousie vessels and nearly all the wood and stone boats, the casualties of wind and weather upon all vessels, and not one-fourth of the whole for entrance or exit, if both channels were free alike, *could* take the canal.

Then there remains the only possible way of compensating for the large outlay of constructing and maintaining this canal and another channel, that is, to make them both free alike, and resorting to compulsory harbour dues upon all vessels or cargoes coming in or going out of port.

What must be the amount of harbour dues collected to pay interest on the capital invested in this canal, to reduce the principal, and maintain two channels to the harbour instead of one?

Will it not be a great commercial advantage to a town like Toronto, surrounded by small harbours, connected by railroad, and in close proximity to the rival Port of Hamilton, and hitherto enjoying light harbour dues, and just relieved of all export dues, to be saddled with enormous charges, and those to sustain two bad channels instead of one good one?

What would the citizens of Hamilton give to exchange their costly canal for the almost free Port of Toronto? With them it is canal or *no port.*

It may justly be asked whence comes the desire to risk the stability of a good natural harbour by making another costly channel, which, at the best, can only benefit a partial navigation? To the east end of the town it can bring but evil if it injure the west of the harbour.

Is the entrance to the west of any benefit to the west end of the town?
Are not almost all the commercial wharves east of Yonge Street?
And is not Yonge Street the pivot around which all commerce centres?

Will any merchant ask or care whether his goods come in at the east or at the west end of the harbour, provided the harbour charges be light? Will he consent to pay enormous harbour dues merely for the accomodation of a partial navigation? In no other light can *commerce* look at this project of a canal. Lastly, as provincial property, can there be a reasonable hope that any Legislature or Government will assent to the making of a second opening into one of the finest harbours in the Province, at an acknowledged risk and heavy cost, unless an urgent necessity can be shown for such risk and for such cost?

Until this vexed question is set at rest, the citizens of Toronto generally will not turn their attention with due anxiety to the preservation of the valuable harbour they have the happiness to enjoy.

I have endeavoured to show, in the light I see it myself, that physically, a canal to the east would be destructive to the port; that its nautical advantages are largely delusive; that it would act prejudicially on the commerce of the town; and, lastly, that the assent of Government to such a project is all but hopeless. I will now turn my attention to a subject more worthy of the care and economy of a great commercial town like Toronto—the improvement of the harbour. Active steps for the preservation of the main features of it, as traced out by the hand of nature, repairing that which is decaying, and improving without dangerous innovation such parts as are susceptible of improvement is the only safe course that the guardian power of the port can pursue. Like the human system in all ordinary derangement, ordinary care may suffice, but, where the danger is imminent, we call in the most skilful aid. So would I, in the important case of the derangement of any vital feature in the harbour, consult the most eminent engineers, nay, a board of engineers, for no expense should be spared to secure the stability of a port upon which the value of so much property depends.

I, in the matter of the improvement of the harbour, only give opinions founded upon long observations, and which observations may be useful to engineers; for it is only by observations on the present operations of nature that we infer of the past, or anticipate for the future; therefore, in furtherance of my opinions and observations, although I did not mean to touch upon the theory of the formation of the peninsula, yet, as the means for its preservation call for some opinion of its origin to account for its present appearance, its constant state of transition, however gradual, and to adopt measures to retard its decay. I here submit them:—

The peninsula is still fed by drift and *detritus* from the east, and still grows from the root whence it sprung, the point where the land falls away at the head of Ashbridge's Bay, striking out in a fair field of growth into deep water, the present formation the result of ages of destruction of the Highlands of Scarborough, even from the undefined time where the lake changed its level from a higher to a lower, of which the whole boundaries of it bear incontestible evidence.

The action of the north-east storm has had the same effect upon the *then* advanced promontory of Scarborough, as the north-east storm has upon it at the present day. Acres and acres have been removed from the flats below Scarborough Heights within my recollection.

The result of ages of this work of destruction has been the formation of the present peninsula and shoal, the latter of which is upwards of a mile in width and six miles in length, the crest of it being the present peninsula. If my theory be correct, the superstructure will be the gravel and stone of Scarborough flats, underneath of necessity *clay*, and below that, most probably, indurated clay. The crest has started in continuation of the land, with its broadest part above water, where now it is narrowest. For, as the peninsula extended west, and the promontory of Scarborough receded from erosion, so did the neck of the peninsula at the east, as it could not stand out prominent from the protecting land. Hence the more rapid retrocession of the peninsula east, and the tendency to a Presqu' Isle formation.

The proof of this retrocession of the peninsula or crest of the shoal is traced in the flat shelving shore, leaving little water as the crest recedes from the south, and meeting

comparative deep water to the north, the peninsula not being acted upon by the sea on that side. The modern marks of retrocession, within my own observation during the last twenty-five years, are the long line of aged trees undermined and thrown down by the sea all the way from the head of Ashbridge's Bay to Privat's Hotel.

On examining the beach on the inside, at the head of Ashbridge's Bay, although the lake has frequently made breaches there, and swept over the whole part from where the trees cease east, increasing the beach inside as it was swept from the outside; yet there is no such thing as that which we see at the breach in Toronto Bay; that is, two long piers of sand formed inwards, showing the range of current in. In Ashbridge's Bay there is no ready vent in an opposite direction for the bodies of water thrown in by the sea, consequently it returns in under current again through the breach, hence no leading marks of a current, but augmentation of the beach within.

In Toronto Bay the wide mouth of it affords rapid exit for the water as fast as thrown in, and hence the long banks of sand above water as leaders, and the mass ejected at their head into deep water.

It is easy to account for the spreading of the peninsula tree-like to the west. The material, being finer as removed from the source of supply, spreads over the lake, as seen by the turbid waters in all easterly gales. These gales are invariably met by a counter gale from the south-west driving back the charged water upon the west end of the peninsula and the mouth of the bay; the reaction of the water from the bay causes the deposit which forms the bar at the entrance. It is useless to speak of the phenomena of ridges caused by the action of the waves.

The bar is now marked out by beacons nearly three-quarters of a mile wide in the centre from the west beacon east, and carries from three to six feet of water on the top, in ridges varying from three to six feet; over the whole top of this the sea ranges and it is encroaching upon the deep water of the bay, for the sand shoots down from ten feet, where a buoy is laid on the slope, to fifteen and sixteen feet water almost immediately. No greater proof need be of the encroachments of the sand, and the resistance it meets by currents. This resistance has been reduced the last summer, and will be removed by every neglected breach, *and would be permanently so, to the ruin of the harbour, by a canal.*

The retrocession of the peninsula is so gradual and uniform that with due care no apprehension for the harbour need be felt for a long series of years, unless neglect allow casual breaches to exist which any extraordinary storm may occasion; then the evil is apparent, as witness the effect of the present breach into the bay; a more rapid erosion and retrocession takes place.

The preservation of the peninsula, it seems, rests with the city authorities; then the city authorities hold the responsibility and control the safety of the harbour. With my opinions, I should as soon think of leaving my fences down and my corn fields open to the depredations of cattle as expose this bay for one season to the consequences of the inroads of the lake.

The repairing of the peninsula, maintaining it to a certain height and width, the soiling, planting and seeding it, to secure the surface against the action of the high south wind, will be improvements compared with the state of neglect to which it has been consigned since the hour that Toronto became a town. The thick growth of timber that the lake spared has been plundered off it, and so little has the peninsula itself been appreciated in its true light that for the last few years it has rather been dealt with as an island of guano than as a barrier upon which the safety of the port depended.

I was once of opinion that the bar should be raised above water by dyking, and the channel contracted from the peninsula, but, with the experience of Erie Harbour before me, where they have closed the entrance to a narrow channel by piers, it is more clearly demonstrated to me that the large body of water driven over the bar by the south-west wind is more valuable in its reaction or under current in resisting the encroachment of the bar upon the harbour, and coursing round through the channel, than if the same body of water were shut out and the maintenance of the current at the channel left to the more varying levels betwixt the waters of the bay and those of the lake, and the small contributions from the Don. But be it understood that it is of necessity that there be no breach or outlet of water to leeward.

As to the shutting out the Don from the Bay of Toronto, that can no longer be thought of, as it would largely affect private interests; therefore, it must be treated as an adjunct, and made valuable to the harbour. Not only should the entrance to it be cleaned out, but the whole of the bed of rushes entirely removed from the head of the bay, and the water be allowed to flow freely in and out of the Don, the wave to beat upon the shore, and in a short time a clean beach would form all round the head of the bay, leaving only the mouths of the Don to be bridged over.

The bay is sufficiently large and contains surface enough to contribute to a great reaction during the prevailing south-west winds in favour of the channel. It is ascertained that the water, according to the wind, fluctuates from one to four inches during 24 hours, by correct index in the centre of the harbour, and that the harbour contains a surface of nearly six square miles, that one inch rise or fall of water causes 144 cubic inches for every foot of surface to flow in or out of the bay; that four inches rise or fall will cause one cubic foot, or one cubic yard in every three of surface, to flow by the outlet of the bay; in other words, one-third of this surface water in cubic yards to flow by the mouth of the bay, principally by the channel; but, if the wind be strong south-west, a more rapid circulation is kept up by the water being blown over the bar, and, dammed back from returning that way by the wind and broken water on it, it forces a passage by the channel.

If this body of water be allowed to traverse to leeward through a channel of 200 feet wide and 12 feet deep, which it certainly would, with such a sluice open, what is to retain the bar, composed of moveable sand, in its position if, instead of back water, there is a current over it, and through the harbour from west to east?

It would certainly be an advantage to the harbour if the system of considering it an arm of the lake were extended to the head of Ashbridge's Bay by making a wide opening of 700 or 800 feet past the mouths of the Don, through the cross beach, the rushes dredged away, and the winds and the waves allowed to play freely over the surface; this large circulation would benefit the harbour and conduce to the health of the town, and the money that would be, unprofitably to commerce and injuriously to the harbour wasted upon an experiment might have been applied with a better chance of profit. The whole of Ashbridge's Bay might, in the course of time, be converted into clear water and profitable land.

It is certain that the marsh is both too valuable and too mischievous to be left much longer in the state it is in contiguous to a large, populous and wealthy town like Toronto.

In looking to the channel I see no inconvenience likely to attend it but through neglect of the means of preservation such as the dictates of science may point out.

The north point of the bar progresses west at the rate of 19 or 20 feet annually. It has taken 22 years to advance about 400 feet, say it will take 50 years to progress westerly 1,000 feet, no further than Mr. Shanly has laid out in extent from the Queen's Wharf west, in his Report for an entrance to the town for the Toronto and Guelph Railroad. We will presume, as a matter of course also, that the harbour pier is carried west parallel with the advance of the point of the shoal 1,000 feet in 50 years.

The buoys and beacons with flags on them show the shape and advance of the bar, and it may be observed how it knuckles out abreast of the old head of the wharf, showing its effect on the shoal, the channel being 150 feet wider there than at the point west of it.

The channel has never yet been cleaned out since Toronto was a harbour. I think it ought to be, and, if it was dredged to a depth of 14 feet in its best water when the lake was at the lowest, that it would require no more looking to for at least ten years, probably twenty, as the longer the head of the pier the more concentrated the action of the flux and reflux.

I cannot close this essay without claiming for myself larger and closer observations, and more devotion of time to the interests of the harbour than has fallen to the share of many individuals for the last twenty-five years, and I trust my age, my experience, and my long observations warrant me in making an urgent appeal to all the inhabitants of Toronto to appreciate the great value of their harbour *as it is*, and to oppose the stubborn bulwarks of common sense to delusive and costly projects of innovation which oppose the *operations of nature.*

There are but two natural harbours on the north shore of Lake Ontario. These are Toronto and Kingston. Hamilton is only a port by means of its costly canal. Cobourg is entirely an artificial one, and one of continuous cost. Port Hope does and will owe all its haven properties to art and cost. Port Dalhousie, on the other side, has claims to that designation at great cost as the terminus of the Welland Canal.

But Toronto, the very best harbour on Lake Ontario, comprising an all but land-locked basin, with a superficies of water of nearly six square miles in extent, possessing what no other port possesses, besides its safe basin within, *an excellent roadstead without*, a channel of easy and safe access, and moderate harbour dues; yet, with all these advantages, there is a suicidal call for speculative and dangerous innovation. It will be instructive to hear arguments in favour of this canal as beneficial to the harbour in a *physical* and *commercial sense*. I speak not of the practicability of construction, for the science of engineering is equal to any task; but the advertisement that calls forth this essay is an invitation to constructing engineers to meet if possible the expressed and known wishes of a large portion of the inhabitants of this town, and the temptations to the undertaking of a work of such importance are very great. But the advertisement also calls for and challenges other opinions.

I, as an official of the port, as an advocate for the safety and preservation of the harbour, with a feeling of great interest for its commerce, with a knowledge that the value of *all* property in the town is based upon the stability of the harbour *as it is*, oppose my opinion, grounded upon my long observations and much reflection, against those who advocate what in my opinion is a dangerous and speculative experiment.

It cannot be denied but that the harbour, good as it is and may be for years and years to come, is one of gradual transition and decay. To preserve it, to improve it, to protract its decay, call in aid—if needful the most eminent science—but touch not with a rash and speculative hand its *vital part*.

As a last appeal, and probably the last I shall ever make, I cannot impress too strongly upon those who hold property in the town to guard against all attempts at making a *second opening* into the harbour. The integrity of the peninsula is essential to its safety; upon it depends the stability of the bar, and the flux and reflux to which the channel is due. *As long as the harbour is as safe and as commodious for all the purposes of navigation and commerce as it now is, to adopt the common sense and homely adage of "letting well alone."*

When this paper was written so far, the breach at the Narrows was open. It is now closed up. This is as it should be, and it behoves the guardian authorities now to raise the beach to a standard height above the reach of the wave sufficient to guard against future evil.

I have no interests to serve but those I ought to serve—the safety of the harbour and the interests of navigation and commerce. Now that the peninsula is intact from end to end, keep it so. If any engineer can be found to assert that a body of water can come in at one end of the harbour and go out at the other without current, or that a current can pass over sand without affecting it, it will be an anomaly worthy of explanation. For certain purposes it is convenient to treat the present channel much as the Czar of Russia treats the Turkish Empire, that it is *sick* and *ought* to die for the benefit of others. But I here assert, and I am willing to subject that assertion to the test of the most experienced engineer, or to be examined upon it by a board of engineers, that, *as long as the peninsula is maintained intact, and as long as there is surface water in the bay, that the last drain of it will pass by the channel.* Neglect in extending the pier co-equal with the march of the shoal may allow the water to flow over less navigable bottom, but, as long as this is attended to and the pier carried west, so will the channel be good, even unto the Humber Bay, which will not be for some generations yet to come. As long as the same phenomena of winds and currents exist as now, the guardian powers of the harbour must be guided by *their past* and *present effects* to calculate on the means of its *future preservation.*

I have the honour to be, Gentlemen,

Your most obedient servant,

HUGH RICHARDSON.

Toronto, 1854.

(Published in Toronto "Patriot," March 31st, 1853.)

To the Hon. W. H. Merritt, etc., etc:

Sir,—Understanding since I arrived in Quebec that you were one of a Committee appointed by the Legislative Assembly of 1834, to report on the improvements required in the Toronto, then York, Harbour; and that, among other things, the Committee had under consideration the construction of a ship canal through the eastern portion of the peninsula; and as such an improvement would, in the opinion of many, greatly facilitate the entrance to the harbour and promote the interest of a large number of the inhabitants of Toronto residing in the eastern portion of the city, I am exceedingly anxious to have it constructed, if it is found practicable with safety to the harbour.

Your views on the proposed canal would oblige the parties interested, and confer a favour on

Your most obedient servant,
J. G. BOWES.

Quebec, 16th March, 1853.

Legislative Assembly,
Quebec, March 17th, 1853.

Sir,—I have the honour to acknowledge the receipt of your favour of the 16th inst. this day, and in reply thereto beg to state for your information that on the 4th January, 1834, Hugh Richardson, Wm. Chisholm, and J. G. Chewett, Esquires, Commissioners for the improvement and preservation of York Harbour, reported in favour of damming the harbour, with a view of diverting the course of the River Don therefrom, accompanied by a document from Captain Richardson, addressed to the inhabitants of the Town of Toronto.

This Report, on motion of Mr. Sheriff Jarvis, was referred to a Select Committee, consisting of Messrs. Merritt, Burwell, Ketchum, and Robinson.

Captains Richardson and Bonnycastle, and others, were examined before this Committee. The latter was requested to prepare a written report, which was furnished by him on the 14th January.

On the 13th February the Committee reported, recommending the grant of a sum of money to finish a pier then in course of construction, to contract the channel at its outlet.

The opinions of the two gentlemen referred to will be found at page 175, appendix to journals 1833-34. Both object to opening another channel, although they differ as to the effects produced by the River Don discharging into the harbour.

The simple question put by the Committee was this: "The harbour has continued in its present state time out of mind; therefore, some natural cause must have preserved its present depth of water. Every east wind raises the water in the lake and produces a current flowing into this reservoir until it attains the same level. A west wind produces the contrary effect, effectually scouring out the channel. Would not opening another channel at the opposite point of this harbour reduce the velocity of the present current to the same gradual rate as any other part of its shore, and destroy the rapid current produced by the present reservoir?"

After reading the valuable report of Sir Richard Bonnycastle, of the Royal Engineers, whose ability was duly appreciated at the time, and after full discussion now, I have no doubt the Corporation of Toronto, in 1853, will come to the same determination as the Committee of 1834—twenty years since; and not assume the responsibility of destroying one of the best harbours on Lake Ontario by undertaking an expensive and useless experiment.

I have the honour to be, Sir,
Your obedient servant,
WM. HAMILTON MERRITT.

TORONTO HARBOUR WORKS.

Toronto, April 11th, 1853.

Sir,—In reference to your letter addressed to the Hon. W. H. Merritt respecting an eastern entrance to the Toronto Harbour, and his reply dated March 17th, 1853, I would offer a few remarks. On reading the above correspondence it would be inferred by parties who were unacquainted with the facts that some new evidence or opinions tending to elucidate the subject were to be found in the Parliamentary reports, such is not the case. Sir Richard Bonnycastle's report, with the plan accompanying the same is in the possession of your worshipful Council, and Captain Richardson's letter can also be procured. I am not aware that the records of Parliament contain any further evidence on the subject.

The whole subject of the improvement of the harbour, as explained in my communication of the 10th of February last, which was laid before your worshipful Council and referred by them to the Harbour Commissioners, is now left entirely in their hands.

A communication has been forwarded to the Government, requesting that an experienced and practical engineer should be appointed to investigate and report on the propriety and advantage of constructing an eastern entrance.

Should the Government decline to interfere in the matter, it will then rest with the Harbour Commissioners to take such steps as they may consider advisable, in which, I have no donbt, they will be supported by your worshipful Council.

I am prepared to prove, and I feel certain my opinions will be supported by other engineers, *that the construction of an eastern entrance will not be an expensive or useless experiment, as stated by the Hon. W. H. Merritt. On the contrary, the construction of an eastern entrance will be found to be absolutely necessary for the preservation of the harbour.*

That portion of the peninsula termed the "Narrows," is being gradually washed away; this can be proved by experienced persons, and at no very distant date there is every probability that a wide and deep channel will be formed at this point, which will be very injurious to the harbour, as the *debris* from the Scarborough Heights and the shore of the peninsula west of the "Narrows" would be deposited within the harbour. In fact, the very result would occur that is anticipated by some persons in case an eastern entrance should be constructed.

By the construction of a channel 200 feet wide and 12 feet in depth, running out the piers on either side into at least 20 feet of water, this will be prevented, and the *debris* will be deposited on the outside of the piers forming the channel, thereby increasing the width of that portion of the peninsula, and forming a barrier to further encroachment.

For the reasons given above, I contend that the construction of an eastern entrance at this point will soon be absolutely necessary, particularly as the increasing trade of the city demands it. At a future period, and connected with the improvement of the marsh, another eastern entrance with a canal, as described and recommended by Sir Richard Bonnycastle's report, may be considered necessary, and, as in the present instance, may be absolutely required. In the appendix to the Report dated March 26th, 1835, it is also stated that, "in making the sewers for the city, it would be very advisable to construct one main sewer through the whole length, down to the marsh, instead of lateral ones into the bay."

While the 7th Report of the Board of Works is under consideration, it might be advisable to discuss this suggestion, or the one recommended in my communication of the 10th of February last—either of them would prevent the present evil of running the drains of the city into the harbour.

I have the honour to be

Your obedient servant,

KIVAS TULLY,

Engineer.

His Worship the Mayor of Toronto,

City Hall.

TO THE COMMISSIONERS OF TORONTO HARBOUR.

GENTLEMEN,—In all matters regarding the welfare of the navigation, the preservation of the harbour and its channel, I think it my duty to represent their condition, and to offer suggestions within my province for their improvement.

As regards the channel, it is most requisite that it be opened out to a width of 400 feet, and to 12 feet in depth at lowest water, the above width being necessary to enable sailing vessels to beat through with foul winds; and the depth of 12 feet must be gained beyond the line of stony bottom, which is immoveable, and extends upwards of 100 feet from the Queen's Wharf; the old channel of alluvial bottom must be opened out again. It is now covered up with sand.

To do this effectually the steam dredge should be employed all next summer; and, to keep it in moderate activity, two more deck scows will be required, the dumping scows being in a manner useless, there being no place to dump into without great loss of time.

The channel is now opened out unequally in depth to a width of 400 feet, but, owing to the difficulty and risk of working the dredge on the edge of the shoal on account of the passage of steamers, there is a ridge of sand at the distance of 260 or 270 feet from the pier with only 8 or 9 feet water on it, which renders the part of the channel beyond it unavailable. It is little surprising that those engaged in dredging, whose only remuneration was in the sale of the clean sand, should be little inclined to risk much. As soon as the mud or alluvial bottom was reached there was a stop, and the dredge removed to a more profitable part.

However, 30,000 yards of sand have been taken up during the last two seasons free of expense to the Commission. There is another strong inducement to place the dredge in full activity next season. The water is very low, which will afford unusual facility for working it; and, should the average rise and fall of the lake be this season in the ratio that it has been for the last four years, it will be lower next winter than it now is.

In the winter of 1850-51, the height of the water stood at nine feet at a certain place at the Queen's Wharf. This I established as my *zero* for low water. In the winter of 1851-52 it was twelve inches higher and marked ten feet; in the winter of 1852-53 it stood at eleven feet. The two summers of these years, having no floating gauge, I did not accurately mark the rise of the lake. To June 6th, 1853, the water rose, by the gauge, 24½ inches, and the index marked 48½ inches above *zero*. This was its *highest rise*. It fell to January 6th 30½ inches, and rose to June 24th of the same year 18 inches. It fell, and kept falling to the unprecedented period of April 6th, 1855, and to the extraordinary fall of 32¼ inches—that is, it fell 14¼ inches more than it rose. It rose to August 3rd, that year 25¼ inches, and fell to February 23rd, 1856, only 13 inches. It rose to June 10th, that year, only 16 inches, and fell to January 1st, this year, 24 inches. Thus the average fall for the last four years, since the high water, has been five inches more than the average rise, and the gauge stands at five inches above *zero*. The greatest rise in one year has not exceeded 25¼, nor has it been less than 16 inches; its greatest fall 32½ inches, and its least 13 inches during these four years.

There are two epochs of time attended with some danger and much inconvenience to the harbour, the extreme height of the lake endangering its boundary, and the extreme fall causing inconvenience in the channel and about the wharves and docks.

I consider it imperative to the scouring out and preservation of the channel that the west end of the pier should be kept in advance west of the point of the shoal or bar. That point is now some distance west of the pier, and when this occurs the shoal encroaches more freely upon the channel.

During the fresh south-west wind the current sets out of the channel against the wind, and the stronger the wind the stronger the current; and passing the west end of the pier, it sweeps around it to the shore; the pressure betwixt the pier and the shoal relaxed, the point of the shoal naturally follows the trend of the current, which is shorewards. It is to prevent this action that the pier is extended west.

I do not say that this extension is a necessity this season, but next year I should consider it imperative.

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I cannot fail to bring to notice the rapid recession of the peninsula or island. During the late easterly gales the beach receded close up to the walls of Quinn's Hotel, the doors and windows were beaten in, and everything outside swept away. It is more than probable that during the spring gales the house will be rendered uninhabitable, if not struck down. If all this has taken place with a falling lake, with its rise we may look to great physical alterations in the aspect of the island which may sensibly affect the harbour. As to the question of an eastern cut now in agitation, my unscientific opinions have been long before the public. Science and the interests of commerce may find no difficulty in overruling them. In the meantime, whilst the canal is yet a vision, the channel of the port is a fact. It will require every possible attention, in the low state of the water, to put it in good navigable order.

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HUGH RICHARDSON,
Harbour Master.

Toronto, 8th January, 1857.

TO THE COMMISSIONERS OF TORONTO HARBOUR.

Gentlemen,—In reporting upon the state of the harbour, I cannot avoid mentioning as connected with it, the great change that has taken place in the aspect of the late peninsula, now a confirmed island.

In addition to the former wide and extending breach by the lake into Ashbridge's Bay, the late gales in December last have, as reported to me by the island watchman, opened another breach in the same bay further west, sweeping away fifty trees, nearly the last of the last remaining clump. In this new breach he reports four feet water. The sea now ranges freely over most of the remaining beach in all easterly and southerly gales, and the marsh is detached in large masses and floating about the bay.

In a sanitary point of view alone this may be of great advantage, for, agitation being inimical to marsh growth, the action of the wave will destroy all within its range. Already a very large space within the bay is open water.

Those who remember the peninsula thirty years ago, with its broad neck, its groves of trees, its cattle feed, and the lake road under a high bank, will now, on visiting it, find all replaced by a permanent and wide opening to the lake, and a low, narrow strip of beach extending west almost without a tree, over nearly the whole of which the sea ranges during north-east gales.

Treating the late peninsula as an efflux of drift (the work of ages) from the once extended promontory of Scarborough, I may assert that from the time of the first breach into Ashbridge's Bay the operations of nature at the peninsula were *constructive;* since then they have been all *destructive.*

The peninsula destroyed marks the first great phase of change in the barrier that forms the southern boundary of the Port of Toronto. Its connection with the mainland cut off, bereft of all materials of supply, the future results of nature's operations on the island must be *destructive.*

The drift now, both from the east and west, makes to the open breach as to a common centre, the finer material being carried into deep water within the bay by the carry of the wave, without by its recoil, there in the lake to form reefs and sand bars; the coarser material of gravel and stone marking the line of the lake peninsula, over which the water ranges to a depth of from 2 to 5 feet.

It is not in nature's present operations that the remains of the peninsula above water should preserve its late almost rectilinear form; the shore, both east and west, trending towards the breach, it follows that the line of coast must eventually, however slow, recede to the curve of a bay, and, there being no high embankment west of effectual resistance, as there is to the east, we must be prepared to see the south shore of the island bounding the Bay of Toronto, particularly at the Narrows, wasting and receding in a curve towards the opening in Ashbridge's Bay. It is probable that the drift flowing in there may in time form a bank or bar at no great distance within, and thus re-unite, with the curve of a bay, the island with the mainland again.

All attempts to stay this waste and receding of the south shore of the island, particularly at the Narrows, will, I fear, be fruitless. Awaiting the slow change in the form of the line of coast, all that can be done at the present, without a hazardous waste of money, is to close up any open passage of water in and out of the Bay of Toronto, east, and await future results for further action.

The people on the island report the whole line of beach west as wearing away, and the light keeper at Gibraltar Point announces that point to be greatly reduced. At the same time a resident at Blockhouse Bay reports the great increase of the tongue of the island that forms that bay towards the interior of the harbour, indicating by that sign a draught of current from west to east; the water, during strong south-west gales, finding egress by the mouths of the Don through the marsh, and out at the opening in Ashbridge's Bay, instead of being forced to return by under current to the mouth of the bay, and by the navigable channel.

The embankment at the Narrows is much damaged; it was never finished, and I fear it is of too frail a construction to resist the attacks now of the north-east storm, or to prevent the receding of the beach. I would not advise its repair, other than as I have said to close any run of water. The great volume of drift brought from the west by the south-west wind rapidly fills up any gap that is temporarily made by the easterly gale.

The channel is in a better navigable state than it has been for years, yet the steam dredge will have to be occasionally used. I may remark that the lake is as high now as at its greatest height in the month of June. It has not fallen two inches, whereas at this time last year it had fallen 28 inches, an occurrence as to its height at this time I have never before observed.

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HUGH RICHARDSON,

Harbour Master.

Toronto, 14th January, 1858.

TO THE COMMISSIONERS OF TORONTO HARBOUR.

Gentlemen,—In reporting upon the state of the harbour, I may premise that during the extreme high water of last year, when the lake stood 54 inches above the lowest level observed in 1850, extraordinary destruction on the island took place, and since then the breach at the Narrows has largely increased, even with the falling lake.

This open breach naturally excites much public discussion, and opinions are divided as to whether it should be left open for further observation on its effects on the harbour or whether attempts should be made to close it.

From my own observations during the past summer, I am convinced that all outlay to preserve the island from erosion and recession would be a waste of money, and any attempt to restore the peninsula to its original integrity an insane project.

The peninsula—an alluvial formation of remote origin—whilst it remained intact was the viaduct of alluvions from the east, which fed its growth. When it became so extended and its western limit so far removed from the ever lessening sources of supply that the waste was greater than the supply, erosion of the eastern part was the result, and the first eruption of the lake into Ashbridge's Bay the consequences of its attenuation.

The destruction of the peninsula east conduced to the partial destruction of the island, for it was impossible that it could stand out prominent in the lake free from erosion, whilst that part of the peninsula bounding Ashbridge's Bay was destroyed.

No outlay can now preserve the south-eastern line of the island coast; but a breakwater raised within the bay north of the breach would effectually prevent any sea rolling in prejudicial to the harbour. This of course must be a costly work, and can be done at any time, but in my opinion will not be needed.

As far as the shelter of the port is concerned, were the whole island submerged, the shoal remaining and acting as a breakwater would still render the harbour a good and safe refuge.

When the first breach occurred at the Narrows, there was a jubilant cry of "new channel." Now that the channel, such as it is, bids fair to be permanent, there is an unreasonable alarm for the stability of the island.

Without the costly aid of art there will be no permanent navigable channel; and however certain the island may be doomed to perish, ages may elapse before that period, and certainly the generation is not yet born that will live to see it.

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The breach at the Narrows does not admit the sand to float over the extent of the harbour; there is merely a rolling over of the surface material into deeper water in close proximity to the breach as may be proved by soundings. Further west, where the island is broad, and the shoal water or continuation of the island under water broader still, the action of the lake there is two-fold—erosive, and a banking up; and, if recession takes place, it is so gradual a falling back upon a broad base, that the island may be considered with reference to the safety of the harbour as permanent.

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During the north-east gale of the 30th December last, the water coursed past the Queen's Wharf continuously at the rate of from two to three miles per hour the whole day, and no doubt swept through Ashbridge's Bay and past the mouths of the Don, as well as in at the breach in Toronto Bay, with sufficiency to keep up this continuous stream. This gale swept down Clendenning's house; and in spite of the current out, the water rose five inches at the wharf.

As a set off to the evil of the open breach, a great benefit will be derived from the influx of pure water from the lake, to counteract in some measure the baneful contributions of the sewers of the growing city, which are all calculated to discharge into the harbour; as well as the water flowing from the Don and marsh in all easterly winds, loaded with decayed vegetable matter, with all of which the north or town side of the bay is liberally inoculated.

In all essentials to the improvement and preservation of the port, and in aids to its navigation, the harbour has been strictly attended to. The channel has been dredged out, widened and deepened; the pier rebuilt, widened, and extended west co-equal with the advance of the shoal in that direction. * * * * * *
And if it continue to advance west (it is now about 100 feet west of the pier head) the pier will require to be extended in that direction also.

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HUGH RICHARDSON,

TORONTO, January, 1859. *Harbour Master.*

TO THE COMMISSIONERS OF TORONTO HARBOUR.

GENTLEMEN,—In reporting upon the state of the harbour, I need scarcely observe that the two last seasons of high water, having effectually destroyed the neck of the peninsula, have at the same time opened out a new navigable channel from the east, carrying in it during the greater part of last season from seven to eight feet of water. I have no doubt the stability of this channel will be confirmed, as the scouring action of a strong current is observed to make through it in all high winds, both from the north-east and south-west. On the west side of it a bank of sand, about 800 feet long, is thrown up, forming a natural pier butting upon the shoal water west of it, where is the broad base of the island under water. This natural pier directs the course of the current in the channel, and as shoal water lies both east and west of it (the channel), and deep water directly north in the bay, for which the current makes, there is no fear of the channel taking another direction.

On 10th October there was only five feet six inches water in this channel, but on the 24th November, when I again surveyed it, after the north-east gale of the 19th, there was six feet, although the lake had fallen six inches in the interim, thus showing the detergent effect of the current.

* * * * * *

The port is now bounded on the south by an island, with a navigable channel both east and west of it.

The present eastern channel, well buoyed out until the depth be confirmed to about eight feet at low water, means might then be taken to render it navigable by night.

* * * * * *

The average rise and fall of the lake for the last seven years has been about 26 inches, and although the annual rise during that time has varied from 18 to 40 inches, and the range of fall has been from 20 to 30 inches, yet 26 inches is about the average of both.

The lowest water was in the winter of 1855 and 1856, and the highest in the summer of 1858, when the lake rose in that one season 40 inches. The range from the highest to the lowest during the seven years has been 54 inches.

From these observations it does not appear that there is any stated periodical cycle of years for very high or very low water, as said to belong to Indian tradition; but these periods are simply governed by the annual accumulation of rise above or of depression below the average, accounted for by the unequal atmospheric phenomena of downfall, evaporation and prevailing winds in the great valley of the St. Lawrence and the western lakes.

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The lake fell 27 inches from the 1st June to the 12th November; from that time to the last of December it rose about three inches, an unusual circumstance, as it usually falls to the end of January.

HUGH RICHARDSON,

Harbour Master.

TORONTO, 2nd January, 1860.

TO THE COMMISSIONERS OF TORONTO HARBOUR.

GENTLEMEN,—As regards the present state of the harbour, I may incidentally remark that the destruction of the peninsula has caused a great change in the approaches and currents of the port, which latter must affect its channels (favourably I trust) and in some measure change the future aspect of the harbour.

Speaking of the west end of the harbour, I may say that since the construction of the pier in 1832 the point of the shoal bounding the channel on the south has gone west abont 570 or 580 feet.

In 1853 it was found to be about 450 feet west of the west end of the pier, and to have seriously encroached upon the channel.

To counteract this encroachment the pier head was extended 400 feet west, and the steam dredge employed two seasons to cut away the shoal and to open out the channel from 260 feet (as it then was) to 400 feet in width, at an average depth of 12 feet, which was accomplished and reliance placed on the deflection of certain observed currents from the pier, the rebound of the wave together with the action of the steamers' paddles to maintain in a great measure this width and depth. The result has proved favourable, as both are now much the same as when the channel was dredged out.

Yet, at this present moment the point of the shoal appears to be west of the pier head from 170 to 180 feet, threatening to encroach upon the channel, being beyond the influence of the offset of the current and wave from the pier.

To guard against this threatened encroachment of the shoal, I submit for the consideration of the Commissioners whether it would not be advisable to extend the pier head another 100 feet or more west. This great length of pier should so direct and concentrate the force of the strong currents that now make through the channel in all high winds, whether from the north-east or south-west, that no deposit could well take place within the limit of their influence.

I have always thought that where sand has to be or can be dealt with, that it is safer to use the motive power of a current, if any, to direct it as needed, than to raise obstructions with a view to arrest the advance of the shoal, which latter process may cause accumulations more than reckoned upon and force uncertain and irregular channels where little needed. Upon this principle I think the western channel has been maintained in a fit state for navigation at no great cost and less risk now nearly 30 years, and upon such I think the eastern one may be maintained and deepened, whilst at the same time the east end of the island will be protected.

There is another powerful reason for extending the pier parallel with the advance of the shoal west. Sailing vessels bound to the port, with an easterly wind and a strong current setting out of the harbour, can with difficulty after clearing the shoal catch the pier head to haul through the channel. Once through, the east end of the pier looks upon more open water, and they can make sail with advantage.

What effect the alternate strong currents now making through the harbour in high winds from the north-east or south-west may have upon the future advance of the shoal west time alone will tell, but in the meantime the precaution of extending the pier may obviate for a length of time the expensive action of the steam dredge, coupled with the necessitous extension of the pier, without which it would be useless and impossible to dredge.

* * * * * *

As to the eastern channel, it is so confined in its present natural state that it demands serious consideration whether steps may not be taken with advantage to improve it.

The natural pier of sand thrown up by the north-east sea, in the shoal water at the east end of the island, and on the west side of the channel running into the harbour in a north-west direction about 1,300 feet, is a natural breakwater without the coast for the time being, yet indicating the proper position of an artificial one; it directs the current,

protects the east end of the island, and has greatly modified the swell that ranged into the harbour at the first making of the breach.

However disastrous to the harbour in its normal state the irruption of the lake into it in that quarter may have been thought at the time of its occurrence, it must now be looked upon as a new feature in it and be turned to advantage, for the commerce of the port will not willingly forego the benefit of an eastern channel, if it can be secured and improved by any reasonable amount of outlay such as the revenue and trade of the port may warrant.

Scientific opinion will no doubt be taken before any serious operations in that direction are entered into; I merely give mine, relying upon higher authority to confirm or condemn them.

There is now six feet of water in the east channel, and the lake is 30 inches lower than at the highest in 1858, and 24 inches above the lowest observed since 1850. The east channel does not silt up, and the highest water would now give three feet six inches against seven feet four inches as in 1858.

HUGH RICHARDSON,

Harbour Master.

Toronto, 10th January, 1861.

TO THE COMMISSIONERS OF TORONTO HARBOUR.

Gentlemen,—Whatever its future, or the temporary necessities of war may require, Toronto Harbour is at this present moment better adapted for all the purposes of peaceful commerce than it has been since it was known as a port.

As if to baffle all scientific suggestion for its improvement east, nature undertook to remodel it after her own fashion and has turned it out as we now see it, still well sheltered from the lake; and, although the peninsula east is gone, the unhealthy marsh is destroyed and we have a new navigable channel, the water in the bay is purer in summer and freer from ice in the winter, and the health of the city better assured.

Having for so many years urged the necessity of the integrity of the peninsula to the well being of the port, it is only when seeing its destruction beyond the power of restoration that I bow to what I have always considered an evil, and advocate the turning to best account that against which there is no apparent remedy.

Since the first breach I noticed in Ashbridge's Bay some thirty-five years ago, the peninsula has been visibly submerging, and the harbour in a state of transition from a deep estuary, bounded by a peninsula, to a port as it now appears, bounded on the south-east by an island, on the north-east by another island, with a navigable channel betwixt them, and on the south-west by the great shoal or bar.

The new channel east is gradually working its own fair-way; has steadily deepened since its first navigable opening in 1859 two feet (the height of the lake being taken into account); and I feel confident that in time there will be a fair natural channel in that direction, although narrow, to be buoyed out betwixt protecting shoals and islands, which may prove not only beneficial to commerce, but possibly a great auxiliary to the naval defence of the lake and city.

As regards the western, its preservation is now more needful than ever, the tendency of the bar from the island being to close in upon it. The north point of it is now 200 feet west of the west end of the pier, and beyond the influence of the current deflected from it, for which the pier was built and extended. The channel has been opened at a great expense by steam dredging from 200 to 400 feet in width, and is maintained by the current at that width; and I think it of absolute necessity for its preservation that the pier be extended 200 feet further west, parallel with the advance of the shoal in that direction. There are funds in hand sufficient for the purpose, and if it be done now it

will save much future trouble and expense. It may be some considerable time before another extension be required; for although the bar progresses west, yet since the harbour has been open to the lake at the east the bar has much wasted down, the winds and surface currents so acting in concert that instead of depositing as heretofore there is now removal. It is during this process of wasting down and the sand spreading on all sides that the value of the extended pier should be felt. Moreover, the difficulty sailing vessels experience in catching hold of the pier in fresh easterly winds, against wind and current setting out, is another argument in favour of its extension.

I come now to a most important feature of the harbour—the island. Without surmising a stand-still in nature, I trust it is destined to afford shelter to the port for many years yet to come, although admitting that extreme high waters, severe easterly gales, added to the palpable sedimentary rise of the bed of the lake, must in time be fatal to it; still, with all this in view, seeing the broad base of the island, the shoal water from which extends over nearly one-third of the harbour, its slow recession upon this base, the long line of sand bank above water at the eastern extremity running north-west 2,000 feet at right angles to the north-east sea, thereby acting as a breakwater to the port in that direction, the erosion at the south and east, compensated in part by the accession of growth at the west; all these indicate the slow destruction of the island, and lead me to presume that the Harbour of Toronto is destined for many years to come to be the best and most commodious in Lake Ontario; and, profiting by the promptings of nature and engineering science, the two navigable channels may be preserved to the port as long as it exists.

The water in the lake is two feet six inches below the highest by me observed, and two feet above the lowest; it has fallen sixteen inches since June last.

There is from eleven to thirteen feet in the west channel, and six feet ten inches in the east one.

Apart from facts, I have ventured opinions for which long observation must be my apology; those of a competent engineer will no doubt be taken before such a work as I suggest be entered into.

HUGH RICHARDSON,

Harbour Master.

Toronto, 9th January, 1862.

(No. 61,410.)

REPORT BY S. KEEFER, DEPUTY COMMISSIONER OF PUBLIC WORKS.

DATE SHOULD BE 1862

Quebec, 22nd October, 1872.

Sir,—In reference to the petition of the Council of the Corporation of the City of Toronto, praying that His Excellency will be pleased to direct a survey to be made of the Harbour of Toronto "with a view to ascertaining the cause of the dilapidations which have already taken place, and of devising some means of arresting their progress," I have the honour to report—

That there can be no doubt of the fact that the City of Toronto owes its existence, and the surrounding country its present growth and prosperity, mainly to the fine natural Harbour of Toronto: and it must be admitted that, while this harbour has served to develop local trade, it has also served the important purpose of a harbour of refuge for the shipping and general commerce of the lakes. It may therefore be considered as both of *local* and *provincial* importance.

That while it has served in the course of less than 70 years to build up a city with 45,000 inhabitants, and a local trade of over six million of dollars in value, it would appear from authentic reports that the powers of nature which have been beneficially operating for centuries in its formation for the service of man are now alarmingly active in its

destruction. From my own knowledge of this harbour, derived from personal observation extending over a period of thirty years, as well as from the published reports of engineers and other scientific gentlemen who have given their attention to it, I think the petitioners have good reason to feel alarmed at the progress of destruction which since the period of high water in 1857 has been going on before their city: and that they are right in making some effort to arrest it. I paid a visit to the breach at the east end of the harbour in May, 1858, the spring after it took place, and found it then about 300 yards wide, with from two to three feet of water on the bar; but owing to the continuance of high water since that date, and to the current through the opening, the depth over the bar has increased so much as to admit of steamers passing in and out at this end of the harbour—still it is not unlikely that as the water falls this channel may be filled up again, and afford the requisite protection to the harbour.

The first survey of this harbour of which we have any knowledge is that of the late Joseph Bouchette, made in 1793, one year before the founding of the city by General Simcoe, Lieutenant Governor of Upper Canada; when, he says in his work on the *British Dominions in America*, "the spot on which the city now stands, presented only one solitary Indian wig-wam * * Dense and trackless forests lined the margin of the lake, and reflected their inverted image on its glassy surface * * and the bay and neighbouring marshes were the hitherto uninvaded haunts of immense coveys of wild fowl."

Other surveys have since been made by Bayfield, 1828, Bonnycastle, 1835, Gzowski, 1846? and Fleming, 1850.

To give some idea of the extensive changes that have taken place within this known period of its history, and of the magnitude of the forces in operation, I quote from the report of Professor Hind, published in the transactions of the Canadian Institute in 1854:—

"In 58 years upwards of 30 acres have been added to the peninsula in deep water beyond the lighthouse. The shoal towards the bay has increased to a very threatening extent, and has spread in the direction of Humber Bay and Lighthouse Point; a new reef is forming which perhaps this season will effect a fresh addition of 10 to 12 acres to the westward of the peninsula, and which only requires a period of low water to develop itself in the form of a beach. Now all these enormous changes in so short a space of time imply the existence of no ordinary force, or supply of materials, for they have occurred in deep water, and involve the removal of many millions of tons of sand and shingle."

Assuming these measurements to be correct, and that this material was deposited in water varying from 20 to 30 feet in depth, which is not at all an unreasonable supposition, the actual quantity delivered at the "dump" beyond the lighthouse would average not less than 20,000 cubic yards per annum.

Mr. Fleming states that in 1796 the western channel was 480 yards wide between the ten feet water lines, and that in 1850 it had been reduced to 120 yards in width. "Fifty-three years ago," he remarks, "the entrance is shown to have been four times its present width, thus decreasing at the rate of from seven to ten yards annually by the deposit of 11,000 cubic yards" of sand and shingle in the navigable channel. He adds "we have substantial reasons for believing that if left unheeded it will in 10 or 12 years be inaccesible except to the smallest craft."

On this point I beg to remark that if the peninsular character of the harbour can be preserved—and of this I have no doubt—and if the western entrance be narrowed and preserved within proper limits by artificial means, the tidal current in and out of the bay will in my judgment always preserve a sufficient draught in the channel, the same as at Burlington Bay, for vessels of the largest class.

According to the best received theory of the formation of this singular peninsula (but now for five years an island by reason of the breach at the east end of the harbour) a theory the correctness of which in my judgment is fully established by the facts and deductions of the two authorities last mentioned, as well as by my own observations, the whole of this annual supply of 20,000 cubic yards of material comes from the Scarborough Cliffs to the eastward of the harbour, and is transported at the periods of low water by the force of the easterly gales along the narrow beach which separates the waters of the

lake from those of Ashbridge's Bay and the Toronto Harbour proper. But when the water is high this dividing ridge between the waters becomes too narrow for safety, and is liable to be broken through by the action of the sea, as formerly at Ashbridge's Bay and latterly in 1857 at the east end of the harbour.

It is apparent therefore that so long as this latter breach continues open and the remaining portion of the breach to the eastward remains intact, to form the road of communication between the cliffs and the breach, the whole of this 20,000 yards of material must annually be thrown into the harbour.

These are the important considerations that seem to call for another and most careful survey of this great natural harbour. Such a survey should be conducted under the direction of one of our ablest hydraulic engineers. The subject requires to be treated both theoretically and practically, with a view to the satisfactory delineation of the causes which have operated in the formation, but are now apparently directed to the destruction of this harbour, as well as devising some plan for directing them beneficially in future for its preservation and protection. The problem, not being easy of solution should therefore, be committed to the ablest hands.

The only question that remains to be considered is whether this survey should be made at the expense of the Government or of the local authorities. On this point I would respectfully observe that surveys have heretofore been instituted by this Department, under the authority of the Legislature, for harbours of refuge on Lakes Ontario, Erie and Huron, but so far without any definite result—the object being to find out new places where they can be rendered available. It would seem reasonable, therefore, that as regards harbours of refuge the same policy that sanctions expenditure for extending their benefit to the general commerce of the country, in the survey of new places, would also sanction it for the preservation of those we have and on which that commerce now entirely depends.

Respectfully submitted,
By your obedient servant,
SAMUEL KEEFER,
Deputy Commissioner of Public Works.

Hon. N. I. Tessier,
Commissioner Public Works,
Quebec.

TO THE COMMISSIONERS OF TORONTO HARBOUR.

Gentlemen,—On the present state of the harbour I beg leave to submit the following observations:—

The eastern channel I deem to be at the present moment quite in the hands of nature. Since it was first opened to navigation in 1858 with a narrow navigable channel of seven feet of water, the lake then 51 inches above the lowest level observed by me, the breach has been gradually enlarging, and in last season there was a good channel of 8 feet water 300 feet wide, with the water 30 inches lower than in 1858. But the channel over the site of the late peninsula does not now regulate the draught of water requisite for vessels entering the port from the east. A bar of sand has grown up 200 yards within it, parallel to the old line of peninsula, over which the shoalest water is a little less than the shoalest in the buoyed channel.

The breach in the late peninsula is about half a mile wide, with deep and shoal and irregular soundings throughout, and the old line of beach has so far receded that the boiler of the wrecked steamer *Monarch*, once high and dry upon the beach, with its top about ten feet above the surface of the lake, now lies above 100 yards out in the lake in deep water.

As to the space now open filling up, or the old line of the peninsula being restored is entirely against the present operations of nature, and the effects of the north-east storm

to which the peninsula lies exposed by the receding of the line of coast to the east. Irregular shoals of sand may form within it, yet a navigable channel, I think, may be reckoned upon, more or less deep, during the season for navigation, although it may be tortuous and require to be well buoyed out.

These shoals over which the sea breaks will prevent much inconvenience to the shipping in the port.

Whatever be the future results of this irruption of the lake, it has some present compensating advantages, such as a navigable channel during the summer, increased health to the city by the destruction of the pestiforous marsh, and the greater purity of the water in the bay.

Attempts to arrest the operations of nature, which know no standstill, must be attended with great cost, such as the local means can scarcely provide, together with the risk of failure in the end. What practical science may suggest for the improvement of the harbour east I can form no conjecture.

The west and original channel requires to be artificiallly preserved against the threatened encroachment of the bar into it. The bar having grown west beyond the influence of the pier, it tends towards the shelving north shore, and will force the channel over a shoaler and more uneven bottom ; for this reason the pier must be extended west, presenting a bluff to deflect the current against the shoal and keep the channel in fair navigable water.

Those who know what an imperceptible current will put fine sand in motion will account for the progress ef the bar west, itself the index that the currents prevail more from east to west than from west to east, although the prevailing winds are ten months in the year west of the points north or south. From this it would appear that the water driven east and returning west by the under current has a preference of action upon the bar, as shown by its gradual march west.

I have ever been adverse to alternate currents passing through the harbour as destructive to the bar, and against the theory of its formation. That which I foresaw would be the result upon a small scale by a canal opening at the Narrows of 200 feet in width is now in operation upon a much larger one, the effect of it in a few years has been to widen the channel considerably, to carry the point of the bar to the west, and to depress the bar sensibly.

The bar is an essential part of the harbour, essential to its shelter as a port ; and the bar, as a counterpart of the bar, is essential to the preservation of the channel, and an aid to its entrance.

When I first navigated the lake in 1826 the harbour was a deep, close estuary (or *cul de sac*) with a perceptible current constantly setting out towards the west, increasing with the strength of the south-west wind. This current meeting the wave of the wind charged with sand from the island, a bar across the mouth of the bay arose from deposit, the result of the conflict betwixt the wave and the current, the work of ages perhaps. Over this bar the water, within my observation, was very shallow ; so much so, that in the periods of low water an island covered with sedge appeared in the middle of it, and a boat (except in high waters) could scarcely pass over any part but near the island, where there was a boat channel of four or five feet of water. Of late it has been gradually lowering, the result of alternate currents passing over it.

The following statement will show the effect of the opening east upon the channel and the bar since 1860 :—

May 29th, 1860, the lake 22 inches above *zero*, the channel, measured by a marked line, was 400 feet wide, with eight feet water at the shoal. On the 11th August, 1862, the lake 27 inches above *zero*, the same, measured to the nearest buoy, laid down in nine feet water, was 480 feet, thus showing that it had widened at the narrowest point abreast of the pier 80 feet and more in two years.

On the 11th April last year, the lake 27 inches above *zero*, the white buoys were all laid down in nine feet water. On the 27th October, the lake 17 inches above *zero*, the water at the 1st and 2nd white buoys nearest to the pier was eight feet eight inches, and seven feet for some distance south ; at the 3rd further south, eight feet six inches, and at the fourth or farthest south eight feet ; thus showing that although the lake had fallen 10 inches in the interim the depth of water at the nearest buoys had only decreased four

inches, bearing evidence of the abrasion of the point of the bar of six inches during 6½ months. But at the red buoy west, laid down in 10 feet water, there was nine feet two inches, shoaling suddenly up to five feet, and it was found to be 65 feet west of its position of 1861, and 300 feet west of the west end of the pier.

By the above showing, if I am correct in my soundings and measurements, the point of the bar is 300 feet west of the pier end, and carrying the line of the pier west it is found to have advanced 40 feet north, encroaching thus much upon the fair-way of the channel.

I think all this points to the necessity of extending the pier further west. It was originally suggested to carry out two piers, one south to arrest the advance of the bar north; but, if equally beneficial results have been obtained by guiding the operations of nature rather than by opposing them, it has been done at less cost and less risk from obstruction, and a second pier would have been a detriment to navigation.

I suggest that the pier be extended at least 200 feet further west and bearing towards the south, and that the range lighthouse (now an useless eyesore) be so placed as to afford every facility to vessels entering the harbour and to take the channel in the darkest and stormiest night.

The lake having fallen 32 inches the last season, and being three feet six inches lower than in 1857, when the peninsula was mostly destroyed, a large surface of it is exposed in Ashbridge's Bay, but its restoration is adverse to the destructive operations now going on, which the next high water will accelerate.

The opinion of a competent engineer will no doubt be taken on the subject of the improvements which I recommend.

HUGH RICHARDSON,

Harbour Master.

Toronto, 15th January, 1863.

TO THE COMMISSIONERS OF TORONTO HARBOUR.

Gentlemen,—In reporting upon the state of the harbour, I may say that by the timely extension of the pier westwardly in 1863 the main channel has been secured for some time to come in a good navigable width of 400 feet, with a depth of 13 feet water at the present low state of the lake.

The progress of the shoal or bar west has been noted for many years, and since 1833, the year the pier was first projected, the north point of it, bounding the channel, has gone west about 700 feet, which averages at the rate of 23 feet annually, less when the harbour was closed at the east, and more since it was open to the lake at that quarter.

In the winter of 1829-30, the channel being frozen over, I measured the width and sounded the depth of it, by cutting holes in the ice every two rods, or 33 feet, and found it to be 775 feet in width, from 9 feet of water in shore commencing at the creek, whence the pier was afterwards started (there being no pier at the time) to 9 feet of water at the shoal, and the greatest depth was 14 feet 6 inches.

In 1833, by a grant of money from Government and by commission, the jetty of the present pier was run out into 7 feet water, and in 1838, by a further grant, and by commission, it was carried out into 9 feet of water, and the pier head was extended 200 feet east with the view to form a winter harbour, and when properly finished, by dropping the pier some 200 or 300 feet east it will be capable of holding a fair fleet of vessels, and open to the lake nearly all winter. At that time the channel was 600 to 700 feet wide.

From that date until 1850, the year of the appointment of the present Harbour Trust, no steps were taken to arrest the encroachment of the bar upon the channel, and the channel was buoyed and beaconed at private expense.

In the year 1853 the bar had contracted the channel west of the pier to 260 feet, while abreast of it at the narrowest part it was 460 feet, thus showing conclusively at that time the effect of the pier in deflecting an almost imperceptible current against the face of the advancing shoal and arresting its progress north.

In that year the pier head was extended 400 feet west, showing that the channel was contracted to 260 feet.

In 1855 and 1856, at the cost and labour of a steam dredge, together with the cost of the extension of the pier and the removal of about 40,000 yards of sand from the bar, a sum of £10,000 was expended, but the channel was opened to 400 feet in width. From that time it has so remained, and since the opening at the east has even widened to 450 feet abreast of the pier; but in 1863, the bar having gone west of the pier head about 300 feet, it was observed to have encroached upon the fair-way of the channel some 60 feet. To counteract this the pier was again extended 200 feet further west, with an inclination of 30 feet south, which contracted the channel at the west entrance to 390 feet, since when, by a survey on the 10th September, 1864, it was ascertained that the scouring currents had widened it to upwards of 400 feet, and the lengthened pier also enabled a better adjustment of the range light for the direction of the channel.

Of the eastern channel little favourable can be said, for there is a bank of sand thrown in for at least 500 yards distant from the old line of beach with only 6 feet of water upon it at the low state of the lake, which makes it of little value but to vessels of light draught of water.

The basin of the harbour, if it were protected from the flow of *detritus* from the Don and the flooding of alluvium from Ashbridge's Bay, would probably be a good harbour, even were the southern and western boundaries under water, protected, as it still would be, from the effects of high seas by surrounding shoals.

Those who remember the harbour forty years past, with its broad peninsula extending in high banks, well clothed with trees from the prominent land east, with its cross beach reaching from the peninsula to the Don—separating Ashbridge's Bay from Toronto Bay—will scarcely now recognize the harbour for the the same; the peninsula east with its groves of trees being gone, and the cross beach since the irruption of the lake into Ashbridge's Bay being nearly swept away.

With such data before us of its destruction during the past few years, and looking forward to another half century, we may imagine the result. Yet, Toronto Harbour is too valuable to the Province, both in a commercial and in a military point of view, to be abandoned to the destructive powers of nature now in operation without an effort to retard their progress.

The greatest and most essential measure, in my opinion, for the future preservation of the harbour would be the artificial reconstruction of the cross beach.

That beach is now in a great measure under water, particularly the northern portion of it, and the consequence of the partial destruction of the barrier separating Ashbridge's Bay from Toronto Bay is that immense quantities of alluvium are thrown from the former into the latter bay during every easterly high wind; the bottom of Ashbridge's Bay, with its recumbent marsh, being much higher than that of Toronto Bay, and their unchecked communication withheld while the beach existed, must now gradually but fatally in the course of time lead to the destruction of the latter.

Since the partial destruction of this barrier, the east end of the harbour has shoaled out to a considerable distance.

I remember when 12 feet of water was to be found close up to the cross beach, as late as 1853, of which I have a note in my journal.

If, commencing from the northern branch or mouth of the Don, a dyke were raised by a system of piling and filling in, or such an effectual dyke as engineering science might devise, if carried out into the lake by a heavy pier to 12 feet water, I am strongly of opinion that the alternate currents now coursing through the eastern outlet with every change of wind, would—directed by the pier and dyke—secure a fair natural channel by sweeping through the bank of light sand which encumbers it, and at the same time arresting the flow of sand from the east into the bay. This would be a costly undertaking, and could only be a Provincial work. For this reason a Government survey of the harbour is much to be desired, that the opinion of disinterested and scientific men may be had. In

default of some such measure a deluge of alluvium will be cast into the harbour from Ashbridge's Bay with every high easterly wind, which, added to the *detritus* brought down by the Don and its tributaries must accelerate the filling up of the basin of the port.

In fact, to secure to Toronto Harbour its greatest permanency the delta of the Don must be confined to Ashbridge's Bay.

The necessity of the sewers of this large city shedding their foul accumulations into the bay is an evil in more senses than one, but to remove the soil at the mouths of the sewers, where it lies quiescent and harmless to the navigable water, and to cast it into the bay, would do more harm in one day than the sewers (if left to their own operations) would do in years. The soil when removed must be landed or cast into sheet piled or cribbed enclosures.

I have entered at more length than usual in my observations on the harbour, and have ventured opinions on the subject of its preservation, correct or not, which my long acquaintance with the harbour may warrant. From the year 1826, when I first navigated the lake, until 1833, there was not a pier, nor were there any buoys or beacons, or harbour lights, but such as were furnished at private expense, and it was due to the late Lord Seaton (who took an interest in the navigation of the port) that the original part of the present pier was projected.

From my first acquaintance with the harbour I have ever advocated its preservation and improvement in preference to innovation and risk of failure, and I still urge the same policy, and much may yet be done towards the preservation and improvement of this valuable harbour.

HUGH RICHARDSON,

Harbour Master.

Toronto, January, 1865.

TO THE COMMISSIONERS OF TORONTO HARBOUR.

Gentlemen,—Of the harbour little can be said as to its natural improvement. In the eastern gap, which was at first navigable for vessels drawing betwixt 8 and 9 feet of water, owing to the extreme lowness of the lake and other causes, there was at the end of November only 4 feet of water over the outer ridge, and on the inner bar 6 feet of water seems generally to rule. There is no probability of the eastern outlet closing up, but it may be useless to navigation. Since the destruction of the peninsula the island has been gradually wasting away. The source whence the peninsula and island owed their formation ages ago (the prominence of the cape at the Highlands of Scarborough) no longer exists the line of coast having receded, so as not to afford a supply in the direction of the late peninsula, and the same causes that led to its formation, (the easterly storms and the prevalent currents from east to west) now act to its destruction; and as there is no standstill in Nature we can only look to the gradual submergence of the island in the course of time, leaving a broad shoal as the southern boundary of the harbour.

As long as the harbour is a harbour, the western channel will claim all attention, for without it we have no harbour. This channel is now 400 feet wide, and carries from 11 feet 6 inches at low water, to 14 feet 6 inches at the highest; the tendency of the shoal from the island to encroach upon it is kept at bay by the force of the current, deflected from the extended pier, now 660 feet west of the jetty; and the shoal, in the course of 34 years, has progressed 700 feet west, which is at the rate of 22 feet annually. As long as the shoal marches west the pier must accompany it, otherwise it will cross the channel as formerly, when it contracted it to 260 feet, which necessitated the cost of a steam dredge, and the removal of from 35,000 to 40,000 yards of sand to open it to 400 feet.

The lake is extremely low, being now at *zero* (originally *nine* feet at a certain part of the Queen's Wharf before it was deepened by dredging). The water has fallen 29 inches this season, and is 13 inches lower than at this time last year. The lake in the

winter of 1837 was only two inches above *zero*, but that year it rose 40 inches, and continued to rise next year. Within my knowledge the water has been 54 inches higher than it is now, yet the average rise and fall is 26 inches. Much inconvenience is felt in the harbour both in extreme high and extreme low water. We may hope for a great rise this year, and I expect it.

HUGH RICHARDSON,
Harbour Master.

Toronto, 11th January, 1866.

TO THE CHAIRMAN OF THE HARBOUR COMMISSIONERS.

Gentlemen,—According to the records of the height of water in Lake Ontario kept at the harbour master's office, the surface level has been lower this year than for many years past, the average being 9½ inches above the datum (zero) of the water gauge, or 9 inches above the rock at the Queen's Wharf.

The average level last year was 15 inches above the datum, the highest level in May being 28 inches above, and the lowest 1 inch below the datum.

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The records respecting the level of the water in Lake Ontario would appear to indicate that one of the periods of low water was reached in the early part of this year, and as the level of the water atpresent is about 12 inches higher than at this time last year it is more than likely that in about two years the level of the water in the lake will reach the maximum, which would give an average of 2 feet 9 inches above the datum at the Queen's Wharf, or 1 foot 9 inches above the present level, affording ample depth at all the wharves for the purposes of navigation.

* * * * * * *

During the approaching period of high water some damage to the wharves, etc., may be expected during storms as the eastern channel has been gradually widening and deepening, and the bar opposite the Queen's Wharf on the west has been much washed and spread out by the action of the currents east and west through the harbour since the eastern channel was formed (1853), when the highest level, 48½ inches above the datum at the Queen's Wharf, was recorded.

It must be evident to even a casual observer that the erosion of the peninsula to the south of the city has been steadily progressing as stated year after year by Captain Richardson, the Harbour Master.

In his report last year the Harbour Master states: "Since the destruction of the peninsula the island has been gradually wasting away; and also, as there is no stand still in Nature, we can only look to the gradual submergence of the island in the course of time, leaving a broad shoal as the southern boundary of the harbour."

In February, 1853, when the breach first occurred at the Narrows, to the east of the centre of the present eastern channel the opening was about 50 yards wide and three feet deep.

I stated in a published report in 1853 that the breach then formed was not likely to be filled up from natural causes, and in various reports this opinion has been reiterated, and lastly in 1857 when I stated "that the destruction of the peninsula must be looked upon as inevitable, unless the erosion was arrested in its progress."

The extension of the Queen's Wharf towards the west has been beneficial in maintaining the channel, which continues 400 feet in width, with (at present) a clear depth of 11 feet of water.

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KIVAS TULLY,
Engineer.

Toronto, 31st December, 1866.

TO THE CHAIRMAN OF THE HARBOUR COMMISSIONERS.

Sir,—The fluctuation in the level of the water of Lake Ontario was greater during the past year than has ever been recorded in the Harbour Master's office. The highest water, according to the gauge at the Queen's Wharf, was 38 inches above the datum on the 10th June, and the lowest five inches below the datum on the 26th of December, making a difference of 43 inches during the short period of six months and 16 days; as the water is still falling, it is likely that the lowest point—10 inches below the datum—will be reached.

The average for the year was 19 inches above the datum, and 9 inches above the the average of 1866, indicating an upward tendency in the level of the water, consequently it is probable that the average of 1868 will be higher than 1867.

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The deposit on the point of the bar south of the Queen's Wharf is still increasing in a westerly direction at the usual rate—about 30 feet per annum. At present there is not any indication of the formation of a bar across the channel, the extension of the wharf westward 200 feet in 1863 having fully answered the purpose of directing the current so as to keep the channel clear.

The formation west of the Lighthouse Point has increased considerably during the last few years, and an additional tongue or arm has formed, which trends in a northerly direction about 300 yards west of the island, making another bay; this formation will no doubt continue to increase.

The erosion of the eastern channel still continues, and notwithstanding the lowness of the water the opening is both wider and deeper than formerly, the apparent decrease in the depth of water in the opening being attributable only to the subsidence in the water level of Lake Ontario. The deposit on the arms east and west of the opening still increases in a north-westerly direction, and affords additional protection to the shipping in the harbour during easterly storms.

KIVAS TULLY,
Engineer.

Toronto, 4th January, 1868.

REPORT ON TORONTO HARBOUR BY WILLIAM KINGSFORD, ENGINEER IN CHARGE.

(*Departmental Report, 1874-75, App. p. 94*).

Toronto, 7th July, 1875.

Sir,—The vote of Parliament of $20,000, for the improvement of Toronto Harbour during the present fiscal year, and the Departmental instructions to me as Engineer in charge entail upon me the duty of reporting without delay on its condition.

The subject is one of so much difficulty that I should have desired to defer my report until the completion of the second examination now in progress. It has, however, been my duty on several occasions to bring the matter under the notice of the Hon. the Minister, and I have frequently discussed with the Deputy Minister the best mode of application of the vote. Last year a careful survey was made of the whole extent of the harbour, and I have also endeavoured to consider the subject in all its bearings. Therefore, I do not feel warranted in delaying the expressions of the opinion which an examination of the facts and data at our disposal leads me to entertain.

The subject may be said to divide itself into two points for consideration :—

1. Whether it be expedient to create an artificial entrance to the east of the harbour, or whether the present channel to the west, navigated by vessels of greater draught, be sufficient for the commerce of Toronto.

2. Whether the common rumour that the harbour is in danger of becoming useless for vessels of heavy draught, owing to its decrease of depth, be warranted by fact, and if so what special works are necessary to assure its preservation, notably in the locality called the Eastern Gap.

Any proposition which affirms the threatening condition of the harbour, when repeated in newspapers and in private conversation, usually finds adherents, but, giving to those who advance these opinions all credit for sincerity and public spirit, it will be found that their statements are based on generalities, and the few observed or well ascertained facts are put forth to sustain the positive opinions expressed.

The geological formation of Toronto Harbour to some extent favours this view. The eastern spit of land which protects the harbour is formed of sand, much of which is frequently in motion. It has been asserted that, carried away from the original place of deposit, it finds its way into the harbour. The examination of last year proves that such is not the case. There is no less depth of water to-day in the inner harbour than is shown on the map of the first survey made by Bouchette in 1785.

The changes which have taken place since that date are not to be traced in the harbour proper. They are to be found in the outline of the coast of the island, in the form and extent of the marsh adjoining Ashbridge's Bay, and in the spit of land connecting the two, and what is of greater importance the shoal at the west entrance has been much extended, so that the navigable outlet to Lake Ontario has been narrowed and reduced in depth.

Some plausible theories have been advanced setting forth laws by which the movement of material to the shoal has been controlled. Moreover, one or two predictions have been realized, which to superficial observers may seem to establish that other results similarly predicted may similarly come to pass.

A quarter of a century ago the eastern entrance was totally barred by a strip of land, and a well known tavern then stood where there is now six feet of water.

As it could be observed that changes were in constant operation to modify the position of the sand of the shore line, it was pronounced that eventually the encroachments of the lake would sweep away the sand bar and the buildings which stood upon it. In this prognostication, the first step towards the destruction of the harbour was traced.

The western entrance has been equally the subject of prophecy. Found yearly to become more contracted and less deep, its entire silting up has been confidently foretold.

The eastern entrance has fulfilled expectation. The tavern has disappeared, and there is a wide gap of water where dry land formerly cropped out. The western entrance has also been narrowed and its depth decreased. The conclusion is therefore drawn that the deposit has been transferred from the one locality to the other—that the *detritus* has been moved from the eastern gap and deposited at the Queen's Wharf; that the roll of the greater wave of the water of the lake east of Toronto, during south-easterly gales, has carried the material to the west, prevailing over the more general south-westerly gales and the set of the current of the lake from the west. No recognition is

given to the possibility that the Queen's Wharf shoal has received its increase from another source.

An attempt was made in 1873 to dredge a deep channel through the east opening so that a permanent deep channel could be made available. The theory appears to have been entertained that the removal of sand which had taken place was the commencement of the total removal of the spit, and that the channel once excavated could be easily maintained and kept open. But the attempt ended in failure.

The excavation rapidly filled up, and it seems to my mind, when considered with the fact that none of the deposit carried away by natural influences finds its way into the harbour proper, that the predicted destruction of the harbour, or, more properly speaking, the probability of its depth being decreased is purely theoretical and entirely at variance with known influences. We do not possess a series of observed facts to generalize on this matter. But there seem to be enough established data to show that the constantly shifting position of the sand is confined within certain limits. A series of quiet seasons in connection with other physical influences may tend to make new land between the marsh and the island. But there is nothing to warrant the belief that the formation will be stable and permanent or become available for use.

On the other hand, a series of opposite influences will act in the contrary direction. They will disintegrate the sand so thrown up, and if the forces be of long duration will more or less change its position. But the sand bar will still remain in one form or the other, generally intact, forming a protection to the inner harbour in a greater or less degree.

The inner harbour itself has been subject to a series of influences since the first survey of Bouchette, differing in character and totally independent of those mentioned. They may be described as the discharge from the sewers, no small deposit in a large and populous city; and secondly, the effect which may be traced to the construction in front of a city of a continuous line of esplanade, with its projecting wharves, which increase in extent as the western end of the city is gained. Prominent among these structures are the Northern Railway Station grounds and the Queen's Wharf.

The latter wharf projects far into the lake, and a curve is given to it which turns it parallel to the aggregation of sand known as Gibraltar Point. The consequence is that the channel has been narrowed at the most important part of these waters. With the knowledge and experience now possessed, if the question arose to-day as to the expediency of constructing this work, it would not be difficult to establish that the site ought to be left open and not in any way be contracted.

It is not possible to determine the extent of the influence exercised by the Queen's Wharf from its position in attracting matter to the narrow channel opening into Lake Ontario; nor is it necessary in a report of this character to enter into any of the geological theories advanced to account for its deposit. It may, however, be said that wherever shoals of this character deposit themselves from matter held in suspension, the material clings to the structures which have been made to guard against its encroachment.

In many known localities on the western lakes, notably Chicago, it has been found that when a shoal has been dredged out, and the piers lengthened, and every means taken to make the existing influences as little injurious as possible, that the deposit of matter still continued, though in varied form, the difference being that the shoals were turned in other directions, determined by the new structure, and even occasionally increased in magnitude.

Hence it has been assumed by those who have watched the operations of such deposits that shoals of this character are really insuperable, and that all that can be effected is to keep them down by continual dredging, and that no measure final in its consequence in the view of permanently removing them can be looked for.

When the navigation of Lake Ontario was limited to a depth of nine feet of water on the canal sills, the channel at the Queen's Wharf required no greater depth than 10 feet. A channel 30 *(sic)* feet wide has been maintained generally at this depth at great expense, constant dredging having been found necessary. The argument has accordingly been advanced that if steps can be taken to impede the passage of sand from the east, or

otherwise divert its movement, that the channel when dredged out, will not again fill in, but will remain open. Accordingly, it is to the east of Toronto, that every effort of improvement must be made to stop the disintegration of the sand, while special precautions must be taken at the shoal itself to prevent its increase if it be found that it is not practicable entirely to restrain the movement of the material.

I am unable to acquiesce in this view.

It may be affirmed that what has happened in other localities suggests an entirely opposite result. The course recommended is the construction of a line of crib work north of Gibraltar Point at the base of the shallow water, thus enclosing the channel between the proposed line of cribwork and the Queen's Wharf. Were the channel dredged out and its entrance at Lake Ontario widened, with this line of cribwork constructed to retain the passage of the sand, I cannot but think that the shoal would still form in the neighbourhood of the structure, and possibly within the channel itself. Such has essentially been the case at Chicago. There is but one course open for the improvement of the harbour. It is to dredge the channel to the required depth; and to give a wider opening to the west, without in any way having recourse to the protection of a line of cribwork.

The proposition to confine the passage of sand by crib work must be affiliated to the theory that the shoal is maintained by the passage of sand from the eastern side of the harbour, the material making the circuit of the island to add to its eastern *(sic)* and northern area, no slight portion finding its way to the shoal itself. To my mind, no theory satisfactorily accounts for the presence of the shoal between Gibraltar Point and Queen's Wharf.

Indeed, the motion of sand is everywhere inexplicable, and the remarkable sand hills found at the back of Picton, on Lake Ontario, furnish a proof of this view.

The well known *dunes* in Brittany and the South of France are cases in point, and one of the most difficult problems of geology is to trace the origin and assign the causes of these deposits.

It is clear that without knowing the cause of an influence it is impossible to guard against its operation, and the view I express, limited by this law, supposes only a possible mitigation of the evil complained of.

The known facts, as I read them, show the necessity of limiting the expenditure proposed to the improvement of the western entrance.

But even when the channel to the west has been excavated to the required depth it is to be anticipated that the expense of keeping it open will always be serious, and that dredging will be constantly necessary. This conclusion demonstrates the inexpediency of entertaining any proposition for obtaining a second entrance at the eastern side of the harbour. I consider, however, that an opening 300 feet wide with a centre depth of 16 feet, of 200 feet wide and with two lateral side depths of 12 feet, each 50 feet wide, protected by two lines of cribwork 30 feet wide, carefully constructed, carried out on both sides to 20 feet water, I consider that such an opening could be made and maintained and by dredging kept to the required depth.

It is not possible to estimate the extent of the annual dredging maintenance of depth which would be required in this work, but it would be serious. Such a canal would cost little short of $1,000,000.

But the question which really presents itself is whether the general commerce of Toronto calls for this great expense; I have found no facts or arguments which, in my opinion, would justify a Minister of the Crown in asking for the expenditure necessary to obtain this second entrance, notwithstanding that I endeavoured in every way in my power to obtain information to throw light on the subject.

Undoubtedly, many interests of Toronto of a highly important character would be benefited by this expenditure, but they are local and not general in their nature. On the other hand, everything tends to show that it is the interest and policy of Toronto to concentrate what resources of her own she can command and what assistance she may claim on national grounds on the present western opening.

I have before remarked that the theory prevailing in Toronto has been that the deposit at the western entrance is caused solely by the destruction of the eastern spit of

land. It never seems, as I can learn, to be argued that opposing forces frequently clash at some points on Lake Ontario, which cannot be far from the position of the harbour. It appears to me highly probable that the long roll of the greater length of the lake, when a violent south-eastern gale has raged for two or three days, is met by the current proceeding from Niagara Falls; and, as the south-easterly gales are rapidly succeeded by south-westerly gales, it cannot be otherwise than that extraordinary eddies over immense areas of the lake must be created. Such eddies cannot but affect the coast line as they meet it. It follows that a large extent of material is displaced and carried in suspension. Moreover such influences must greatly disturb throughout the area the sand which lies at the lake bottom coming within their reach. As the weather moderates this material must be deposited, and the position of Toronto suggests that it is precisely the place where such deposits would be made.

If such a possibility be admitted, we have as good an explanation for the existence of the shoal at the Queen's Wharf as any other theory can furnish. Under the view which I have attempted to set forth, all necessity of care for the Eastern gap disappears. Indeed, it may be said that any influence of the lake which removes the eastern deposit north of the gap is beneficial to the health of the city. Malaria is generated by marsh, and the effect of the encroachments of the lake has been to remove much of the low ground covered with pools and sedge and aqueous plants, which certainly could not have had a beneficial influence on the public health.

The examinations have proved that the harbour proper is in no way filling up, and although a depth of water is found at the Eastern limit where there was formerly dry land, the shelving bank still remains as a protection to the inner waters of the harbour. It is not necessary that there be a positive outcrop to form protection to an inner basin of deep water. The protection furnished by the shelving ground, whether visible or not, breaks the long wave rising from the continued stretch of deep water, and so diminishes its force that the waters of the inner basin remain comparatively undisturbed. What indeed is there to conserve in the Eastern gap? The opening as it at present exists, tends to the salubrity of the city and permits a free passage of the lake in and out of the harbour. The depth of the water on the bank, as I believe, will continue to vary, but so long as the ridge remains the question of depth is secondary. In certain seasons, vessels of a given depth will pass over it, while in other seasons they will be unable to do so. But the main features of the formation will remain, and however modified its summit may be by the operations of nature the shelving ridge calls for no artificial interference to keep it within defined lines and levels.

If it be admitted that the previous arguments are warranted by the observed facts, it results that the improvement required in Toronto Harbour should be confined to dredging the western entrance to the depth required.

The present approach to Toronto by deep water necessitates an abrupt turn to enter the "Queen's Wharf channel." In the improvement contemplated, easy entrance and egress should be secured.

The increased navigation of the canal system of the Dominion points out that the entrance ultimately should be 16 feet deep. I am not prepared until further examination to state the amount of excavation required to attain this depth.

During the progress of the survey, my opinions have been much modified. At the commencement my whole attention was directed to the Eastern gap. On all sides I heard that in the control of this opening lay the well-being of Toronto. The one accepted theory was that the shoal on the Western entrance was caused by the *detritus* arising from influences in the east and that the existence of the shoal was contingent upon and not directly caused by the changes at the Eastern limit. Moreover, the conversations which I had with the most influential men of Toronto led to the belief that the creation of a deep Eastern entrance was held to be indispensable. My attention was therefore principally given to the examination of this locality, and to the theory that the harbour itself was filling up and would soon be unable to receive vessels of heavy draught. My surveys were much extended in order to prove whether such was or was not the case. Consequently, my examination was more immediately turned to this part of the harbour. Hence, it is necessary to make additional examinations in the Western portion. Mr. Hamel, of my staff, is now engaged in this work testing the depth and extent of the

channel, and in examining the changes which have been made since our last examination. Until I obtain his report, I am not able to state the amount of excavation exacted by the work. But this deficiency of detail does not at all interfere with the conclusions, which I am prepared to submit, that the real wants of Toronto lie in the direction I point out, and that in my humble judgment the $20,000, voted by Parliament should be wholly expended in dredging the western entrance. Eventually I conceive that the depth of 16 feet will be necessary, but this depth is contingent on the full development of the St. Lawrence navigation. The structures of the several canals are designed to have a depth of 14 feet, but, as I understand, the vote of Parliament only provides that at present the navigation of the St. Lawrence shall be adapted to 12 feet on the canal sills. On this basis, the depth at the Queen's wharf channel should be 14 feet.

If Parliament establish canal navigation at 14 feet, the Toronto Harbour should be 16 feet deep. If, on the other hand, the depth of the canal be limited to 12 feet, the depth of the harbour will require to be 14 feet.

As the work recommended by me will require time for its execution, it is important in my view that it should be conducted so that the increased depth be obtained by the period when the new work of the Welland Canal is completed.

At the same time, the harbour calls for immediate attention, from whatever quarter reliefs may come, and no time should be lost in straightening the entrance and widening the mouth connecting it with the main waters of the lake to an assured depth of 11 feet, the additional three feet or five feet hereafter to be excavated as the work of the Welland Canal proceeds.

The recommendations I have the honour to make are as follows :—

1. That the $20,000 Parliamentary vote be expended, as above set forth, in dredging the western entrance, and that the work be performed under the direct control of the Department and not be in any way delegated to the Harbour Trust of Toronto.

2. It is clearly demonstrated by the surveys of 1874, taken in connection with the ancient survey of Bouchette, that the harbour is not filling up and that it is in no danger of destruction, and that no special steps are required for its preservation.

3. That the opening of the eastern gap is not an injury to the city and that no work of protection is required to stay the movement of the sand at this point. At the same time, the excavations from the dredging recommended by me can be placed partially within the southern arm of the eastern gap, but generally without it, upon the shelving ledge which forms the eastern side of the harbour, where it would in no way interfere with the navigation. I do not enter here into the question of the effect on the harbour traceable to the discharge from the sewers. Nor do I, in any way approach the more important consideration of the constant silting up of that portion of the harbour, situated at the mouth of the River Don. A large extent of material has been deposited at the mouth of the Don since the last dredging operations there, and a dredge is now at work, deepening the channel. These operations must be held to be local in their character and to be met by the revenue of the harbour. Moreover, they call for no special consideration. The recurrence of these shoals is a contingency periodically to be looked for and the only remedy to be applied is the one adopted by the Harbour Commissioners, the use of the dredge.

Whatever opinion be given with regard to this harbour, it must be based on a few facts and to a large extent be a matter of theory ; and a remedy cannot be applied until the cause of injury be discovered. No means have been found of establishing satisfactorily, under what influences the deposit of the western entrance is generated or what is to be the ultimate form which the eastern arm to the harbour will assume. So far as I am capable, I have given my reasons for the view I entertain. I am aware that this view differs from that of many men of my own profession, whose opinions I respect. It is also at variance with the popular feeling in Toronto, which generally has urged the construction of works necessarily expensive to strengthen the sand bank in the neighbourhood of the eastern gap. On the other hand, I have the satisfaction of knowing that I do not stand alone in the opinions I have expressed.

The question seriously involves many interests of great weight. Indeed, with the exception of establishing the depth of water on the canal sills of the St. Lawrence

navigation, I can scarcely mention a more important subject than that which I have been discussing, bearing as it does individually on the interests of Toronto and generally on those of the Province of Ontario. Hence the obligation imposed on me in examining this question has not been light. On my part I have striven, as far as possible, to ascertain and recommend the best course of action to be followed in the expenditure of the Parliamentary grant of last session.

I have the honour to be, Sir,
Your obedient servant,
WILLIAM KINGSFORD,
Engineer in Charge.

F. Braun, Esq., Secretary
Department of Public Works.

(No. 73,125.)

TO THE MAYOR AND COUNCIL OF THE CITY OF TORONTO.

Sirs,—In accordance with my promise to your Committee, appointed to meet the Harbour Commissioners, I now beg leave to present my Report on the Toronto Harbour.

In the first place, I may observe that Mr. Kingsford, before entering on the work now being done by the Government, had a full survey made of the harbour as it now is, and on a comparison, the result of such survey, with that of Bouchette in 1793, a plan of which I have in my possession, and which was the first survey made so far as is known, little or any difference appears with the exception of the break at the eastern gap.

Few people are aware that the depth of water in Lake Ontario varies five feet three inches from extreme low water to extreme high, and this difference has been recorded on the harbour books during the past few years; but taking the water at an average height when the last survey was made, the soundings are about the same as those taken nearly one hundred years ago; this, I think, establishes the fact that no material destruction of the harbour has taken place during this time.

The breach in the eastern part of the island occured several years since; at that time the water was above the usual height, and during several years heavy easterly winds would cause vessels at some of the wharves to lie uneasily at their moorings. This continued until a spit of sand formed to the westward of the breach, which now acts as a breakwater, and I consider that there is nothing more now required. I am also of the opinion that the sea will not create a greater depth than it has hitherto done, which, in the deepest part, is only about six feet. This depth is usually increased during the summer months by the natural rise of the water to allow vessels of seven feet draught to go through. As this passage saves the Kingston steamers about twenty minutes, the Commissioners being desirous of giving them this advantage have twice, at an expense of about $10,000, tried to maintain this depth, but have always failed; the first heavy gale after the dredging has been completed has been quite sufficient to fill up the channel, leaving only the original depth. I have therefore come to the conclusion that the best course is to leave Nature to give us just such a channel as she thinks fit.

It is my opinion that it will be a long time before any large portion of the island, now remaining will be submerged, and much as I should regret seeing this take place I see no way of preventing it except at an immense outlay in the first instance, and a heavy annual charge to keep the necessary works in order. I could instance, the piers built out in the lake, where they have to bear the whole force of the waves, which piers have cost large sums of money and now require repairs yearly. As all these works have to be made of wood, the portion of work above low water mark has to be renewed about every ten years, in addition to which heavy seas in the spring and fall often displace the cribs and occasion

a continued heavy expense. These charges have to be met by placing heavy tolls on all freight passing both in and out, and I shall be much surprised in the case of such towns where this work has been done if it will not be necessary for these towns to take some other means than the tolls to pay the interest on the debt incurred in the work. I feel quite sure that if anything of the kind was attempted here, and heavier tolls levied to pay interest, it would drive away what little trade is left to us, for my firm opinion is that nearly all cereals will be carried by rail, and leave nothing but the heaviest sort of freight, such as timber, lumber, stone, coal, wood and such like commodities to follow the water courses; even at this time a very large quantity of coal is daily arriving by rail and can be laid down, taking all charges into consideration, as cheaply as by water during the season of navigation; in fact harbours and water communications are not of the importance to us that they were half a century ago, when it would have been impossible to settle the country without them.

Should pressure be brought on the Government to spend money on the Eastern Gap of Toronto Harbour, I would suggest that no revenue of the harbour now existing should be used for keeping up the works, but that a toll be placed on it, and collected from all crafts passing either in or out; it would then be optional with the masters of vessels to go out at the west end free or to the east, paying the toll.

With regard to the west end of this harbour I consider the action of the Government is right, and, their giving us an entrance for craft drawing all the water that the Welland Canal will afford, will be quite sufficient for all our purposes.

As to the present state of the finances I may say that two years since heavy drafts were made on them for dredging, etc. At that time we were about $10,000 in debt, and debentures were ordered to be sold to pay this amount; they were offered for sale by tender, and after trying some time after to sell them at par, bearing interest at 7 per cent., without success, arrangements were made with the Bank of Toronto to carry the amount, until the receipts of the harbour would liquidate, etc. I am happy to say the amount has been reduced to about $2,000, and I confidently expect that by June the harbour will be entirely free from debt, and we hope to have at least $8,000 to spend this season in doing whatever is required. One great source of expense is the dredging at the mouths of drains to remove deposits washed down from the city, which has cost the Commissioners during the past three years $3,170; this, I hope, will be obviated when the main drain of the city passes into the Don, and from thence out into Ashbridge's Bay.

I send herewith a statement of the accounts and report of the past year. I have taken the liberty of sending this under my own signature, as I do not hold any of my colleagues answerable for any of its contents.

I have been annually elected by the Board of Trade as Harbour Commissioner for the past twenty-two years, and have been chairman for fourteen years. My knowledge of the harbour dates from the year 1831, being a period of forty-seven years, during which time I have been a close observer of it, and, although I may be wrong in some of my opinions as to the future management of the harbour, I feel perfectly satisfied that I have been right in conserving the funds and keeping the Trust out of debt. At the same time, as circumstances have permitted, I have always recommended a reduction of the tolls. As an instance of this I may refer to the rate of tolls on coal, which at the time of my first appointment as Harbour Commissioner was 25 cents per ton, while now it is 5 cents per ton, and other imports have been similarly reduced.

I consider reports on the harbour to be of very little value. The late Capt. Richardson, one of the first navigators of the harbour (especially by steam), a highly educated, and at the same time a most observant and practical man, wrote several works on it, but lived to see his theories all exploded. No person, be he ever so learned, can foresee with any certainty the effects the different currents and winds will have, but one thing we do know, that if the harbour is kept out of debt and the tolls at the lowest possible rates we may expect a fair share of business to remain, but, should the opposite course be adopted, the expenditure of large amounts of money, and increase of tolls to pay interest will have the effect of causing our trade to fall more and more to the railways, and eventually the citizens would have to adopt some other tax to keep good their engagements.

I am, yours truly,

TORONTO, 1878. JAS. G. WORTS.

(No. 80,158.)

City Clerk's Office,
Toronto, January 15th, 1879.

Hon. J. C. Aikins,
Secretary of State, Ottawa.

Sir,—I have the honour, by direction, to forward the enclosed Petition to His Excellency the Governor General, from the Council of the Corporation of the City of Toronto, respecting the Toronto Harbour, also a certified copy of a Petition presented to the City Council on the same subject, and to ask if you will be good enough to lay the same before His Excellency,

I have the honour to be, Sir,
Your obedient servant,
ROBERT RODDY,
City Clerk.

To His Excellency The Right Honourable Sir John Douglas Sutherland Campbell, *Marquis of Lorne, P.C., K.T., G.C.M.G., Governor General of the Dominion of Canada, etc., etc., etc.*

May it Please Your Excellency :—

The Petition of the Mayor and Corporation of the City of Toronto respectfully showeth :—

That a Petition of all *the vessel owners and Captains of vessels* at the time in Toronto was presented to this Council, a certified copy of which accompanies this, asking the Corporation to approach the Government of the Dominion, and to urge upon the members thereof to take all necessary steps for the future protection of the Harbour of Toronto.

That your Petitioners are fully alive to the great importance of the facts as stated in the representations of the vessel owners and Captains.

That the Toronto Bay is the only natural harbour west of Presqu' Isle on the north shore of Lake Ontario.

That an extended break occurred in the peninsula which forms the southerly boundary of the harbour several years ago, and that since then the gap has increased till there is only a narrow strip of land, over which the water breaks in heavy easterly gales to the eastward of the said gap.

That the island to the west is also washing away, leaving Toronto Bay little better at present than an open roadstead.

That the running out of two piers, as recommended by Mr. Sandford Fleming some years ago from the bay to the lake into fifteen or twenty feet of water, similar to those at Burlington would prevent the further washing away of the island.

That this would give an entrance to the Toronto Bay of any required depth or width, which cannot be obtained at the western channel.

That the western channel has from the continued drifting of sand from the south side of the island, in spite of the large sums spent by both Government and Harbour Trust Commissioners, diminished from *one thousand four hundred and twenty feet*, in the late Surveyor General Bouchette's time, to *two hundred and thirty feet* at the present time, and, as many vessels are always in the season lying at the Queen's Wharf, it reduces the channel width to *thirty or forty feet*.

That the water rises and falls some years as much as five feet.

That the western channel has been dredged to the rock and blasted, and with average high water not more than thirteen feet is found, which depth will not accommodate vessels of the proposed capacity of the Welland Canal.

That protection to the harbour of some kind is urgently required, or it will assuredly be destroyed.

That the Government of the United States, being fully alive to the importance of the harbours on their side of the lakes, have expended in their construction over FOUR MILLIONS OF DOLLARS.

Therefore we pray that Your Excellency in Council would cause a survey to be made by fully competent engineers as to the best means of protecting Toronto Harbour.

And your Petitioners, as in duty bound, will ever pray.

ANGUS MORRISON,
Mayor.

S. B. HARMAN,
Treasurer.

(Enclosure.)

TO THE CORPORATION OF THE CITY OF TORONTO :—

The petition of the undersigned vessel owners and captains trading at the Port of the City of Toronto showeth :—

That Toronto Bay is the only natural harbour on the north side of Lake Ontario west of South Bay Point where vessels in stress of weather can run with safety.

That the harbour is gradually but surely being destroyed by the washing away of the island.

That the Gap at the east end of the island is twice as large this year as any previous year.

That if steps are not taken immediately to prevent further washing away of the island our harbour will become in time useless.

That Sandford Fleming, Esq , C E., some years ago in a report on the harbour predicted that if a break in the island should occur, and he foresaw it would, the land to the eastward of the said break would also go, and recommended even at that comparatively remote date the cutting of a channel through the island, and running two piers from the bay into the lake, which piers would act as groynes, collect the sand drift and strengthen it at its weakest point.

That it is the opinion of competent engineers that the construction of two such piers would cause the re-formation of land to the eastward and westward of said piers.

That the construction of said piers would give an entrance to the harbour where any depth of water could be easily obtained.

That it would render our harbour what it ought to be—a true harbour of refuge, which vessels could make in any weather.

That the Western channel is very narrow, constantly requiring dredging.

That the Western channel was in the year 1811 fourteen hundred and twenty-seven feet wide ; this year, 1878, it is only two hundred and thirty feet wide.

That the channel has been dredged to the rock, and thirteen feet found to be the greatest depth to be obtained, which will not accommodate vessels of the full proposed canal capacity.

That vessels or steamers bound down the lake using the eastern channel would save upwards of seven miles.

That the longer the construction of said piers is delayed the more expensive will the work prove.

Your petitioners therefore pray that your honourable body will approach the Government of the Dominion, and urge upon the members thereof the great necessity of making an appropriation for the purpose of protecting the Harbour of Toronto.

And your petitioners will ever pray.

(No. 79,669.)

To His Excellency the Right Honourable the Marquis of Lorne, K.T., P.C., Governor General of the Dominion of Canada, etc., etc., etc:—

The petition of the Commissioners of the Harbour of Toronto humbly showeth :—

That the present condition of the Harbour of Toronto, caused by the action of the elements upon the tongue or strip of land forming the same, is a cause of much anxiety to many of the citizens of Toronto and others interested in the navigation of Lake Ontario; and it is feared that unless means be taken speedily to arrest the mischief the very existence of the harbour may be seriously endangered.

A great difference of opinion exists as to the mode by which this danger may be averted, and as any remedy for the evil would be entirely beyond the powers of your Petitioners, and it is conceived is a matter exclusively within the jurisdiction of the Authorities of the Dominion, your Petitioners would pray Your Excellency to take the case into your consideration, and to cause a proper survey and examination of the said harbour to be made by a board of competent engineers, whose duty it shall be to report upon the best mode of repairing the damage already done, and preserving the harbour for the future, and to take such further steps therein as Your Excellency may deem expedient in the premises.

And your Petitioners, as in duty bound, will ever pray, etc., etc., etc.

JAS. G. WORTS,
Chairman.

Harbour Master's Office,
Toronto, 13th February, 1879.

JOHN CARR,
Harbour Master.

(Canadian Journal, Vol. 2, p. 25.)

VARIATIONS IN THE LEVEL OF THE LAKES.

Toronto, September, 1853.

The recent extraordinary rise in the waters of the great lakes has assumed an importance in relation to navigation, boundaries of property, and the preservation of property situated upon their shores, which throws into the shade all considerations of the phenomenon as a purely scientific question. It will be interesting to inquire whether the present remarkable rise is due to causes which do not at present appear, or whether it is the result of extraordinary rainfall, followed by an unusually small degree of evaporation. Other phenomena of a less general description, yet also influencing the level of the lakes in different localities, demand attention. We think that the fluctuations in the water level of our inland seas may be conveniently divided into three groups :—

1. Variations in the general level of the waters of the lakes.
2. Sudden local variations.
3. Influx and efflux of the mouths of rivers and harbours.

We propose to enumerate some of the changes which have been observed in the levels of Lakes Erie and Ontario before proceeding to inquire into the causes which have

occasioned them. It is well known that these changes have produced very remarkable effects upon the coast wherever the drift clays or the softer shales form the lake boundaries, and where the coast is in the form of a sloping beach.

We glean the following notices from Hall's Geology of the 4th District of New York:—

"Twenty five and thirty years ago the beach of Lake Erie was a travelled highway beyond Buffalo, but at this time it would be quite impossible to travel along the same.

"From the united testimony of persons residing along the margins of all the lakes, and from other demonstrative proofs, it appears that for many years previous to 1838, all the lakes had been rising; that about this period they attained their maximum, and have since been subsiding.

Mr. Hiram Burton who resided at the mouth of Slippery Rock Creek for twenty-three years, informed me (Mr. Hall) in 1840, that the water of Lake Erie was then four feet higher than when he came to that place; that in 1838 it was still higher, but he had made no accurate measurements.

"Mr. Higgins, Topographer to the Geological Survey of Michigan, has given the rise of the lakes as five feet three inches from 1819 to 1838; he regards it as probable that the minimum period continues for a considerable length of time, while the maximum continues only for a single year."

Several of the lake shore or beach roads on the north side of Lake Ontario have disappeared in numerous localities, within the memory of living residents. The old Lake Shore Road, from Toronto to Hamilton, is in parts quite washed away, and we were informed by a resident, a mile or so to the west of the Humber, that a road existed about seven years ago below the present old road. The shore is flat at the place just alluded to, and the destruction of the first and second roads may be attributed to the effects of south-easterly winds upon a high level of the waters of the lake. A storm from the south-east would place the new plank road in considerable jeopardy. A very favourable illustration of some of the results to be anticipated by high lake levels in conjunction with prolonged storms, exists now at the peninsula opposite the Toronto City Hall, where a wide gap was formed during the spring of the present year by the waves of the lake washing away sand, shingle and pebbles to the depth of several feet. The canal thus formed is at present about 160 feet wide and 4 feet deep. Its width and depth and even its position are constantly varying with each high wind from the east, south or south-west. Similar occurrences have been frequently observed to take place in the narrow strip between Ashbridge's Bay and the lake on the same peninsula; and at the present moment, and about the same place, a sand and gravel ridge not less than three feet above the present high level of the lake is to be found occupying the spot where open communication existed between the bay and the lake during a part of last winter and the winter of 1849. We may learn from these occurences the probable fate of the canal opposite the City Hall. The effects of high lake levels upon the precipitous clay cliffs which form a very large portion of the coast lines of Lakes Erie and Ontario are interesting both in their relation to property and to the future probable condition of the lakes, as well as to their past history. An average of a yard a year would be a very moderate allowance for the encroachments of the waters upon the land, occasioned by the washing away of the cliffs which form the coast. We have lately witnessed the entire removal of many acres of land, on which large trees were growing, by the encroachment of the waters of Lake Simcoe on its eastern shores. Instances might be multiplied to show that the annual march of the waters *inland* is a very curious item in the physical history of the great lakes, and one to which we are inclined to ascribe far greater importance in many relations than appears at the first view of this phenomenon.

We now proceed to give such results as we have been able to collect from the different observers who have interested themselves in the rise and fall of the waters of the great lakes. The following table shows the mean depth, the least depth, the greatest depth, the monthly fluctuation, and the greatest fluctuation during twenty-four hours, which we have reduced from the measurements made at Port Colborne, Welland Canal, Lake Erie, during the years 1850, 1851 and 1852. The influence of winds, and probably of local variations in the atmospheric pressure, will become apparent upon examination of the column which gives the greatest fluctuations during twenty-four hours.

TABLE of the variations in the level of Lake Erie, at Port Colborne, during the years 1850, 1851 and 1852 :—

Year.	Month.	Mean Depth.	Least Depth.	Greatest Depth.	Monthly Fluctuation.	Greatest Fluctuation in 24 hours.
		feet.	feet.	feet.	feet.	feet.
1850	April	12.25	11.5	12.83	1.33	0.91
	May	12.32	11.83	12.83	1.00	0.56
	June	12.05	11.75	12.50	0.75	0.50
	July	12.16	11.75	12.83	1.08	0.75
	August	11.98	11.25	12.75	1.50	0.91
	September	11.82	10.66	12.41	1.75	1.33
	October	11.74	11.08	13.16	2.08	1.87
	November	11.45	10.75	12.33	1.58	0.75
	December	11.70	9.83	14.83	5.00	4.33
1851	January	12.12	11.08	15.16	4.08	4.00
	February	11.85	9.79	12.16	2.37	1.41
	March	12.28	11.33	13.16	1.83	0.83
	April	12.3	10.8	13.4	2.6	2.25
	May	12.9	12.1	16.4	4.3	3.9
	June	13.18	12.58	13.84	1.26	.75
	July	13.23	12.5	14.25	1.75	1.35
	August	13.	12.08	13.5	1.42	1.17
	September	12.57	11.17	14.25	3.08	1.75
	October	12.73	12.08	14.03	2.00	1.6
	November	12.6	11.17	14.25	3.08	1.75
	December	12.74	11.83	14.6	2.77	1.66
1852	January	12.2	9.75	13.92	4.37	1.5
	February	11.8	10.9	12.5	1.6	1.08
	March	12.1	11.17	13.66	2.49	1.66
	April	12.8	9.83	14.16	4.33	3.16
	May	13.6	13.00	16.33	3.33	2.5
	June	13.8	12.9	15.00	2.3	1.08
	July	13.5	12.16	14.9	2.73	2.75
	August	13.35	13.3	13.5	.5	.5

The lowest monthly mean depth of the waters of Lake Erie on the sill of the lock at Port Colborne, during the interval between April, 1850, and August, 1852, a period of 32 months, appears to have been 11.45 feet, which occurred in November, 1850. The highest observed mean was in July, 1852, when the depth appears to have been 13.55 feet, giving a difference of 2.1 feet.

The least depth recorded occurred in January, 1852—9.75 feet; the greatest depth in May, 1851, and in May, 1852, when the height of the water was indicated by 16.33 feet, affording a difference of $6\frac{1}{2}$ feet, which was due without question to the prevalence of westerly winds. To the same influence we may ascribe the remarkable monthly fluctuations, and, to a great extent, the fluctuations during twenty-four hours. The greatest monthly fluctuation recorded is 5 feet; the greatest daily fluctuation is $4\frac{1}{3}$ feet. It is a matter of some uncertainty whether the daily fluctuations are due to the influences of winds alone; it appears probable that local variations in atmospheric pressure may have something to do with this phenomenon. The situation of Port Colborne, at one extremity of Lake Erie, is most favourable for the influence of westerly winds, whose effects upon the coast of Buffalo and other neighbouring localities are well known. The westerly winds are among the most frequent and powerful which affect Lake Erie, and they occasionally produce very disastrous results at the eastern extremity of the lake.

The levels of Lake Ontario at Port Dalhousie, are given below, for the years 1851 and 1852; they do not indicate the extraordinary fluctuations which distinguish the water levels of Lake Erie. The sheltered situation of Port Dalhousie sufficiently explains this difference.

TABLE of the variations in the level of Lake Ontario at Port Dalhousie, during the years 1851 and 1852 :—

Year.	Month.	Mean Depth.	Least Depth.	Greatest Depth.	Greatest Monthly Fluctuation.	Greatest Fluctuation in 24 hours.
		ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
1851	January	11.8	11.8	11.9	0.1	0.1
	February	11.10	11.9	12.0	0.3	0.1
	March	12.5	12.1	12.7	0.6	0.2
	April	12.10	12.7	13.2	0.7	0.2
	May	13.3	13.2	13.3	0.1	0.1
	June	13.4	13.3	13.5	0.2	0.0
	July	13.2	13.1	13.4	0.3	0.1
	August	.....	.....	.....	.....	.....
	September	12.10	12.8	13.0	0.4	0.1
	October	12 5	12.3	12.7	0.4	0.1
	November	12.3	12.3	12.4	0.1	0.1
	December	12.2	12.2	12.3	0.1	0.1
	Mean yearly difference	1.8	.....	.....	.....	.....
1852	January	12.2	12.2	12.2	.....	.....
	February	12.2½	12.1	12.4	0.3	0.1
	March	12.7	12.4	12.9	0.5	0.1
	April	13.1	12.10	13.6	0.8	0.2
	May	14.3½	13.6	14.4	0.10	0.2
	June	14.6½	14.4	14.7	0.3	0.1
	July	14.5	14.4	14.6	0.2	0.1
	Mean yearly difference	2.3½	.....	.....	.....	.....

The lock master (Mr. George Thompson) at the Burlington Bay Canal, in his report to the Secretary of the Board of Works on the subject of the rise and fall of the lakes, remarks:—

"As far back as 1836, we had exactly the same high water as we have had this season. I do not remember in the interval of 16 years of ever the water being so high; the mean of the rise of each year in that interval may, I think, be stated pretty correctly at from 22 to 28 inches; this season it has risen to 3 feet 6½ inches above the low water mark that I took in 1848. It had not been as low for several years, and has not been as low since, but it must be remembered that it did not fall to that mark last winter by six (6) inches; deducting that from 3 feet 6½ inches, we have a dead rise of 36½ inches for this season. In March of this year the water was very near up to its old standard, which was rather singular; it rose rapidly until about the middle of May: curiosity induced me

to measure it, when I found it 3 feet above the low water mark of 1848. I kept measuring it at intervals as follows:—

May	26th—3	feet	2	inches	above	the	low	water mark of '48.
June	8th—3	"	3½	"	"	"	"	
"	15th—3	"	4	"	"	"	"	
"	21st—3	"	6	"	"	"	"	
"	25th—3	"	6½	"	"	"	"	

It stood at this until the beginning of August. On the 4th it had fallen 2 inches; on the 15th, 6 inches. September 1st it had fallen 12 inches; 9th, it had fallen 4 inches; on the 22nd, 9 inches; on 12th, 14 inches. It will continue falling till November, and sometimes well on in December; it will then remain stationary till a short time before the breaking up of the ice."

In answer to an enquiry we made some short time since of Mr. George Thompson respecting the height of the lakes this year we were informed—

"That the water here on the 7th June was 8 inches higher than in 1852, making it full 4 feet 2 inches higher than in 1848. It began to fall on the 13th of June; on the 19th it had fallen 2½ inches; on the 11th July, 5 inches; on the 21st, 6 inches; on the 29th, 7½ inches; on the 4th August, 9 inches; and to-day, 10½ inches nearly; it is, consequently, about 2½ inches below the years 1836 and 1852—at present. Its usual time for commencing to fall is from the 1st to the 10th July, whereas it had fallen 1 inch on the 13th June."

OBSERVATIONS made at the Queen's Wharf, Toronto, under the direction of Captain Lefroy, R.A.:—

1849.			1852.		
March	14th	1.0	May	10th	9.4½ *(sic)*
"	24th	1.1½	"	15th	3.5½
"	26th	1.3	"	18th	3.7
"	26th	1.4	"	20th	3.7½
April	4th	1.6	"	29th	3.8
"	9th	1.8	June	3rd	3.8
"	10th	1.10	"	7th	3.7
"	30th	1.11	"	12th	3.11
May	2nd	1.11	"	14th	4.0½
"	6th	2.3	"	29th	3.11
"	7th	2.1	"	30th	4.1 Highest.
"	14th	1.11	July	5th	3.11
"	21st	2.2	"	13th	4.0
"	21st	2.4	"	21st	3.10
July	3rd	2.5	August	19th	3 5
August	5th	1.11	September	6th	3.2
"	15th	1.8	"	30th	2.10
September	20th	1.6	November	18th	2.6
October	25th	0.3 Lowest.	"	24th	2.7
November	31st	1.9	December	17th	2.9 Wind.
December	20th	1.1			

These have always been taken on calm days, with one or two exceptions.

Mr. Dade recorded that on July 1st, 1836, the water in perfect calm stood within 3 feet of the top of the Queen's Wharf. If so it stood eight inches higher than it did on June 30th, 1852, and about the same height as on June 1st, 1853.

OBSERVATIONS made at Gorrie's Wharf, by Mr. G. A. Stewart :—

Month of June.				Month of July.				Month of August			
Day.	Hour.	Height of Water.	Direction of Wind.	Day.	Hour.	Height of Water.	Direction of Wind.	Day.	Hour.	Height of Water.	Direction of Wind.
1	9½ A.M.	4.73	E.	2	3 P.M.	4.50	E.	1	4 P.M.	3.99	E.
1	2 P.M.	4.72	E.	4	9½ A.M.	4 50	S W.	2	12 Noon.	4.00	
2	9 A.M.	4.68	E.	5	10 A.M.	4.46	S.W.	3	5 P.M.	4.00	E.
2	4½ P.M.	4.68	E.	6	9½ A.M.	4.37	S.W.	5	12 Noon.	3.95	
3	9½ A.M.	4.68	S.W.	7	12 Noon	4.40	S.	7	4 P.M.	3.96	
4	10 A.M.	4.64	S.E.	16	12 Noon.	4.15	S.	8	4 P.M.	3.93	
6	9½ A.M.	4.68	S.E.	18	11 A.M.	4.25	S.	10	4 P.M.	3.90	
7	9½ A.M.	4.60	W.	20	12½ P.M.	4.17	W.	12	12 Noon.	3.86	
11	9½ A.M.	4.66	E.	23	10 A.M.	4.13	S.W.	15	12 Noon.	3.85	S.E.
16	11 A.M.	4.70	Calm.	27	12 Noon.	4.05	S.	16	12 Noon.	3.81	S.E.
17	10½ A.M.	4.62	S W.	30	11 A.M.	4.00	S.E.	18	11 A.M.	3.80	
20	9¼ A.M.	4.59	S.W.	....	.....	....	.....	20	4 P.M.	3.82	
23	9¾ A.M.	4.60	S.W.	....	.....	....	.....	23	10 A.M.	3.60	
24	12 Noon.	4.55	W.	....	.....	....	.....	25	9 A.M.	3.60	
25	9½ A.M.	4.43	N.W.	....	.....	....	.....	27	12 Noon.	3.60	
28	9½ A.M.	4.50	E.	...	.....	....	.....	29	12 Noon.	3.40	
30	9 A.M.	4 54	S.W.	....	.....	...	.....	31	2 P.M.	3.40	

These observations are taken from a scale established at Gorrie's Wharf, the zero of which scale is left below the sill of the south-west door of the Custom House, and corresponds with the scale on the Queen's Wharf established by Captain Lefroy.

The year 1819 was one of low water on all the lakes, the lowest indeed in memory, and was taken by Dr. Houghton* as his zero of comparison; referred to this zero, the highest level of Lake Michigan was:—

	ft.	in.
In 1819	0	0
1830	2	0
1836	3	8
1837	4	3
1838	5	3
1839	3	11
1840	2	7½

* Report of the State Geologist, Michigan, 1841, p. 162.

Thus it was 19 years in attaining its maximum, but only 2½ in reducing it to one-half. The following variations in the level of Lake Erie, in 1852, were recorded by C. Whittlesey, Esq., of Cleveland*:—

	Monthly. ft.	Mean. in.
January	3	6
February	3	4.2
March	2	11.6
April	1	11.3
May	1	4.0
June	1	1.2
July	1	2.5
August	1	5.1
September	1	9.4
October	2	0.6
November	2	3.3
December	2	4.1

Capt. T. H. Spencer recorded the variations in the level of Lake Ontario, at the mouth of the Genesee, during the years 1846-1852, both inclusive; they are as follows:—

	1846	1847	1848	1849	1850	1851	1852
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
January 1	3 3	3 0	1 5	3 2	2 9	2 8	3 3
February 1	3 6	2 5	1 10	3 2	2 4	3 6	3 3
March 1	3 0	2 0	2 7	3 4	2 4	3 0	3 0
April 1	2 9	2 0	2 2	2 10	2 4	2 11	2 8
May 1	2 6	1 5	2 2	2 0	1 8	2 8	1 2
June 1	2 3	1 1	2 1	1 9	1 5	2 2	1 2
July 1	2 3	1 1	2 2	2 8	1 10	1 11	0 10
August 1	2 6	1 1	2 3	2 3	2 10	2 2	1 0
September	2 9	2 0	2 8	2 9	2 11	2 6	1 6
October	2 9	2 3	3 1	2 2	3 4	2 11	0 11
November 1	3 0	2 7	3 6	2 2	3 7	3 5	2 2
December 1	2 9	2 10	3 5	2 5	2 7	3 3	1 10
do 31	3 0	1 5	3 2	2 9	2 8	3 8	1 11
Average	2 0	1 11	2 6	2 6½	2 6	2 9½	1 11

The measures were taken from the top of the dock, and reduced to one point of observation. Of course the less the measure the higher the level of the water of the lake. The highest was in July, 1852, and the lowest in November, 1850; the difference being two feet nine inches.

* Extracted from the Regent's Report for 1853.

In continuation of the table of observation by Mr. Stewart, we append those for September and part of October. The present gradual fall of the water is very evident; but if we may reason from the very crude and imperfect observations which we have been able to procure, it will soon become stationary and remain so until it begins again to rise in the spring. The greatest height recently attained by Lake Ontario above the low water mark of October 28, 1849, is four feet five inches, according to measurements made at Toronto. Since June 1st of the present year it has fallen in four months and fifteen days only twenty-one inches; whereas, in 1849, the water fell in three months and twenty-six days, twenty-six inches.

Observations made at Gorrie's Wharf, by Mr. G. A. Stewart, 1853 :—

SEPTEMBER.				OCTOBER.			
Day.	Hour.	Height of Water.	Wind.	Day.	Hour.	Height of Water.	Wind.
7	10 A.M.	3.28	.....	1	3 P.M.	3.37	S.W.
8	12 Noon.	3.35	W.	3	11 A.M.	3.17	N.W.
10	12 Noon.	3.28	W.	6	3 P.M.	3.06	N.W.
16	11 A.M.	3.40	W.	7	5 P.M.	3.20	S.W.
20	12 Noon.	3.50	.....	8	3 P.M.	3.20	S.W.
24	11½ A.M.	3.32	W.	15	3 P.M.	2.98	.....
26	4 P.M.	3.42	E.	.....	.....	.....	.....
27	12 Noon.	3.32	E.	.....	.....	.....	.....
29	11 A.M.	3.40	S.E.	.....	.....	.....	.....

Among the most interesting phenomena which may be classed under variations in the level of the lakes are the sudden elevations and depressions which have been recorded from time to time as occurring chiefly on the shores of Canada and the State of New York. It is much to be regretted that accurate observations of these fluctuations do not appear to have been made. The data at our command are exceedingly meagre, and scarcely do justice to the very interesting phenomena to which they refer.

Toronto, January, 1854.

The annual fluctuations in the level of the water of Lake Ontario appear nearly simultaneous and commensurate with the fluctuations which have been observed to take place in the upper lakes. Whatever conclusions are deduced from this phenomenon in Lake Ontario, the same will evidently hold good with respect to Lakes Erie and Huron. Mr. Hall, in his geology of the 4th district of the State of New York, says that a single individual informed him that about the year 1788 or 1790 the lakes were as high as in 1838; associating this fact with the observations which have been recorded on pages 26 and 62 of this journal, in the absence of more detailed information, we obtain the following table :—

Maximum Level.	Minimum Level.
1788 or '90.	1819.
1838	1848.
1853	

Or from Maximum to Minimum	.....	31 years.
" "	.....	10 "
From Minimum to Maximum	.....	19 "
" "	.....	7 "

It seems scarcely possible to discover any relation between these figures which would indicate periodicity in the occurrence of the fluctuations, or in any recorded phenomena of the kind beyond the rise of the lakes in the spring and their fall in the autumn of the year. We are therefore thrown back upon those inquiries which would lead us to imagine that the annual variations in the levels of the lakes are due to an unequal amount of rainfall and an inconstant degree of evaporation. Whatever apparent regularity may be deduced from observed phenomena appears to be altogether dependent upon those climatic changes which distinguish in a greater or less degree every extensive region.

The chief source of supply is the Niagara River, which joins Lake Ontario with Erie. The quantity of water flowing down this stupendous cataract has been estimated by Mr. Barrett, at Black Rock. The result of three separate observations made during the high water of 1838 and 1839 gave 19,500,000 cubic feet, or nearly 600,000 tons per minute.* If we assume 20,000,000 cubic feet per minute to represent the maximum quantity passing into Lake Ontario from Lake Erie, the whole volume from that source alone would be sufficient to raise the waters of Lake Ontario 62 feet during one year, or about 2 inches in one day if there were no outlet and no waste by evaporation. At the same rate of discharge Lake Erie would be drained in about two years and four months. The elevation of the waters of the lakes above their present mean level cannot have taken place to an extent beyond a few feet *during the last geological era.* A curious confirmation of this physical fact is given by the Provincial Geologist in his report for the years 1845-6 : "Lake Ontario is stated to be about nine feet above the St. Lawrence at the Galops ; so that any stoppage in the river below the Galops which would raise the surface of Ontario beyond twenty-one feet over its present level would send a broad sheet of its waters, with a violent current, down the valley of the Petite Nation, an accident which, judging from the apparently undisturbed condition of its clay banks, has not happened since the country *rose from beneath a tertiary ocean.*"

There is no reason to suppose that the level of Lake Ontario has risen many inches even above its present high elevation for many ages. The existence of an occasional sand bank supporting a growth of heavy timber on the shores of both the upper and lower lakes sufficiently confirms this fact. It is, however, to be remarked that the inroads made by the waters during the last two years have far exceeded those made in 1838. It has been found, as was previously stated (page 25), that on the eastern shores of Lake Simcoe many hundred acres of land are now submerged, and in part denuded of their forest growth by the waters which have covered them during the past summer. Lake Simcoe, an inland body of water, 128 feet above Lake Huron, has exhibited precisely the same phenomena as the larger lakes into which its waters ultimately flow. The same rapid breaking down of its banks and cliffs has constantly occurred during the memory of the oldest settlers on its eastern shores as are universally witnessed on the clay cliff shores of Lakes Erie and Ontario. This denuding action, coupled with the *detritus* of rivers, cannot fail to exercise an influence upon the general level of the bottom of the lakes during the lapse of years.

It is well known that a very large portion of the water which falls to the earth in the form of rain or dew becomes again dissipated by the process of evaporation. Accurate experiments have been made by competent persons with a view to ascertain the relation existing between rain fall and evaporation, not only from the surface of the soil under different circumstances, but also from the surface of water.

The following table† shows that the quantity annually passing off from the surface of water may often equal, and occasionally exceed, the precipitation even in temperate climates. The clear skies and hot sun of Canada West would favour the supposition that the annual results of evaporation from the surface of its great lakes really exceed, in general, those of precipitation:—

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* Hall's Geology of the State of New York.

† Thompson, Introduction to Meteorology.

Name of Place.	Evaporation in In.	No. of years ob.
London	23.98	3
Kendal	25.75	3
Tottenham	30.47	8½
Glasgow	32.41	2
Liverpool	36.73	3
Paris	38.	
Boston, U.S.*	56.	
Ogdensburg†	49.30	1

The amount of evaporation from open plains varies from one-half to one-third of the rainfall in this climate. In forest clad regions a much greater proportion escapes as drainage.

The month of May of this year was distinguished not only by the large quantity of rain which fell but also on account of the number of rainy days, and hence the cloudiness of the sky. In a note attached to the Monthly Meteorological Register of the Provincial Observatory for May, we find the following:—"The depth of rain for this month is much above the average and has been exceeded only in two years, 1844-49; but the number of rainy days is the greatest that has been known throughout the whole series of years, being only equalled in August in 1844." It must be borne in mind that a cloudy sky of a few days longer duration than usual during the warm months of the year will arrest evaporation to such a degree from the surface of water as very soon to cause a marked difference in the levels of lakes embracing an area of upwards of 50,000 square miles, and draining a country more than four times as large again.

A glance at the seasons preceding the high water of 1836 and 1852, which differed only by 8 inches in Lake Ontario, will perhaps enable us to recognize the influence of climatic changes upon our lake levels.

The winter of 1835-6 may be said to have commenced on November 23rd. On December 1st, the bay was frozen over, being about a fortnight earlier than usual. The temperature of December was as follows: 3 days below zero, 9 between 10° and 20°, 15 between 20° and 32°, and 4 between 32° and 40°. January, 1836, was not remarkable for severity, the minimum being only 2° and the maximum 45°. This mildness was compensated by the rigour of the succeeding month, in which there were no less than seven days below zero, and only one above the freezing point at 8 a.m. March was likewise unusually severe, and the bay was not clear of ice until the 25th of April. This winter may be said to have continued 155 days. During the whole period there fell no more than 1¾ inches of rain; the number of days of snow was *thirty four*.‡ In an admirable paper on the winter of 1851-2, Capt. Lefroy states that, "The winter of 1835-6 which is said, however, to have been the most severe in North America since 1779-80, was decidedly more severe than that of 1851-2. But the winter of 1851-2 was the most severe since 1835-6."

"So far, therefore, that winter taken in its popular extent maintains its character for severity, but this results chiefly from our having excluded October, and included April. October, 1851, was unusually warm and genial, having had a mean temperature of 47°.8, which is 3°.3 higher than the mean for the same number of years, while April, 1852, has been one of the coldest in it."

It seems remarkable that during the year 1852 the quantity of rain which fell at Albany was less in that year than since 1826. The greatest fall in any one year was in 1850, which amounted to 50.97 inches. The least fall during a period of 26 years was in 1852, which amounted to 31.79 inches, or not less than 6.85 inches below the mean of 26 years§

At Toronto the rain fall in 1852 was also below the mean by rather more than one inch.

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* Dr. Hale.
† J. H. Coffin.
‡ From observations by the Rev. C. Dade.—*Vide* Scobie's Almanac, for 1851.
§ Regent's Report for 1853.

In continuation of tables given on pages 125 and 127 we add the following :—

OBSERVATIONS made at Gorrie's Wharf, by Mr. G. A. Stewart, 1853.

Month.	Day.	Hour.	Height of Water.	Wind.
October	15	3 P.M.	2.98	
"	18	10 A.M.	2.90	
"	20	10 A.M.	2.93	
"	26	2 P.M.	2.90	West.
"	28	12 Noon.	2.90	
"	30	12 Noon.	2.93	
November	1	2 P.M.	2.88	
"	2	4 P.M.	2.78	
"	4	4 P.M.	2.72	
"	5	11 A.M.	2.72	
"	7	4 P.M.	2.70	
"	10	10 A.M.	2.79	
"	12	10½ A.M.	2.76	
"	14	3 P.M.	2.68	
"	15	2 P.M.	2.77	
"	19	2 P.M.	2.75	
"	21	10 A.M.	2.82	
"	22	9 A.M.	2.81	
"	25	12 Noon.	2.76	
"	29	11 A.M.	2.82	
December	1	1 P.M.	2.58	
"	5	11 A.M.	2.62	
"	8	12 Noon.	2.65	
"	13	11 A.M.	2.60	
"	15	11 A.M.	2.60	
"	16	11½ A.M.	2.62	
"	17	11½ A.M.	2.58	

The maximum altitude registered by Mr. Stewart occurred on the first day of June, 1853. The difference between the water level on that day and on December 17th is 2 feet 1 inch, which represents the fall of the water during a period of six and a half months. During the last ten months it has fallen only 5 inches, and the probability is that its minimum for this winter has already been very nearly attained.

It is, perhaps, worthy of note that Mr. Murray, the Assistant Provincial Geologist, in his report for 1848, states that there were indications in the water marks of both Lake Huron and Lake Nipissing that they have "sunk considerably below their ancient levels," and that a corresponding fall could be traced in each successive lake of the chain between them. Lake Nipissing is 69 feet above Lake Huron, into which it empties itself. The difference between the level of Lake Huron in 1848 and the "ancient level" as indicated by water marks on the beach and rocks was 4.10 feet. In Lake Ontario the low water mark of 1848 was 3 feet 6½ inches below the maximum level of 1852, and 4 feet 2½ inches below the minimum level of 1853, as will be seen by comparing the data given in the September number of the *Journal*. It will also be remembered that the maximum level of Ontario in 1853, was exactly equal to the maximum level in 1836; may not therefore the "ancient level" which Mr. Murray observed, registered on the rocks of Lake Huron, be that of 1836 or 1838, which appears to have been the year of maximum level for Lake Michigan, as recorded by Dr. Houghton, who gives the difference between the levels of 1819 and 1838 at 5 feet 3 inches. The level of Ontario in 1838 we have not been able to ascertain, probably it was higher than in 1836. With regard to Lake Nipissing, the connection appears more probable. Mr. Murray, in 1848, made the following measurements against a vertical rock :—

	feet.	inches.
Spring mark of 1848 over existing summer level of 1848.	2	0
Old mark above the spring mark	3	9
Old mark above existing level.....	5	9

The difference between the maximum level of Lake Michigan in 1838 and the old water mark of Lake Nipissing being only 6 inches renders it highly probable that the height of the water of the year 1838 is registered on the rocks of Lake Nipissing—as it is not to be supposed that so easily obliterated an object as a natural water mark on a perpendicular rock forming the shore of a lake would be of very ancient date—without it possessed characteristics which have not been alluded to by Mr. Murray.

In concluding these imperfect notes on the interesting phenomena of the lakes, we have merely to express our entire concurrence in the views which are entertained by many that the annual variations are the result of climatic irregularities, and consequently, entirely dependent on waste and supply. The local variations are unquestionably due chiefly to the influence of winds, and in a far less degree to sudden variations in atmospheric pressure, which produce the phenomena of *seiches*, as described by Col. Jackson, on page 27 of this *Journal*. The violent and local convulsions, which have been witnessed near Cobourg, and elsewhere, appear to result from causes far more obscure, but yet not altogether inexplicable. We shall return to the consideration of these remarkable phenomena at some future period. The very great difficulty of obtaining authentic information respecting "lake convulsions," or any phenomena of a local character which may have been observed and recorded, induces us warmly to solicit from the members of the institute, or the readers of this journal, the communication of any facts or information which they may think worthy of transmission.

The following paper, from the rural economy of J. B. Bousigault, on the "Influence of Agriculture on Climate in lessening Streams," contains matter of much interest, which can already be appreciated in many ways by the people of Canada and of the shores of the great lakes :—

(*Read at Canadian Institute, Toronto, Saturday, March 22nd, 1879, by* KIVAS TULLY, C.E.)

THE FLUCTUATIONS OF LAKE ONTARIO.

FROM THE YEAR 1854 TO THE YEAR 1878, INCLUSIVE.

The great lakes of North America are the reservoirs of the watershed which lies between 76° and 92° west lon. and 42° and 50° north lat., running in a diagonal or north-westerly direction between the above parallels of longitude and latitude, about 1,000 miles in length and 400 miles in breadth, in all about 400,000 square miles, the superficial area of the lakes being about 100,000 square miles.

The following are the approximate dimensions of the several lakes and their heights above the sea level :—

	Length.	Breadth.	Greatest depth.	Height above tide water at Three Rivers.
Lake Superior.....	390 miles.	160 miles.	1,000 feet.	600 feet.
" *Michigan.....	345 "	84 "	1,000 "	578 "
" Huron.....	270 "	105 "	900 "	574 "
" Erie.....	250 "	60 "	204 "	564 "
" Ontario.....	190 "	52 "	600 "	204 "

Lake Superior being the largest, and Lake Ontario the smallest.

The mean monthly fluctuations of the above lakes, according to the late United States survey, are as follows :—

Lake Superior	from 1870 to 1876	.....	1.84 feet.
" Michigan	" 1859 "	.....	2.35 "
" Huron	" "	.....	2.10 "
" Erie	" "	.....	2.50 "
" Ontario	" "	.....	4.74 "

The elevation of the mean surface of Lake Ontario from 1860 to 1875 was 247 feet above mean tide at Governor's Island, New York. The mean surface of Lake Erie was 573.58 feet. The above elevations have been ascertained from actual levels taken in 1875, and may be considered as accurate when compared with previous data, having been checked with bench-marks at New York, Albany, Oswego, Port Dalhousie and Port Colborne, per United States survey.

The extreme fluctuation of Lake Erie or the difference between the records of the highest and lowest water at Port Colborne, between 1859 and 1867, is 11 feet 3 inches, and the extreme fluctuation of Lake Ontario at Port Dalhousie between 1868 and 1870 is 6 feet 11 inches, and according to the records in the Harbour Commissioner's Office, Toronto, between 1870 and 1872, 5 feet $3\frac{1}{4}$ inches. The mean average surface of Lake Ontario above the datum of 9 feet at the Queen's Wharf being 1 foot $6\frac{1}{5}$ inches for 25 years, between 1854 and 1878 inclusive.

An inspection of the accompanying chart or profile of water level curves shows the fluctuation for each year, the mean for each year, and the average for 25 years, also the rain and snow falls.

That the fluctuations can be explained by the rain and snow fall is beyond doubt, as the profiles of the latter will be found to correspond with the former, with the exceptions

* Now said to be reduced to 576 feet by outflow of the Illinois Canal at Chicago.

of the years 1858, 1867, and 1874. When the rain and snow falls decreased and fluctuations increased this may be accounted for in consequence of the deficiencies of the snow and rain falls in these years as compared with the previous and following years; for instance, the rain and snow falls for 1857 were 40.385 inches; 1858, 32.591 inches, and 1859, 39.764 inches; for 1866, 39.419 inches; 1867, 30.091 inches, and 1868, 34.278 inches; for 1873, 31.612 inches; 1874, 24.344 inches, and for 1875, 29.730 inches.

The fluctuations of the years 1858, 1867 and 1874 for Lake Erie, being above the mean average, will also account for the increase in Lake Ontario.

The average rain and melted snow falls for 25 years were 34.172 inches, the highest being 48.490 inches for 1878, and the lowest 24.344 inches in 1874. The rain and snow fall of 1870 being 46.188 inches.

I am enabled to give the complete statistics of the rain and snow falls for 1878 from the recent meteorological register received from C. Carpmael, Esq.

The unusual rainfall of last year, 43.390 inches, nearly equal to the great rainfall of 1843, 43.555 inches, is accounted for by two rain storms, one on the 4th of August, when 3.450 inches fell, and on the 13th September when 3.085 inches fell in a few hours.

The effects of the latter rain storm were disastrous to the bridges across the River Don in the eastern portion of the city, nearly all the bridges having been carried away and communication with the city interrupted for some days. The water at the King Street bridge was dammed up about ten feet above the ordinary level.

The observations as to the level of the water in Lake Ontario were commenced, by the directions of Captain Richardson, Harbour Master, in 1854, though a regular float gauge was not constructed until 1856, and since that time the gauge has been twice shifted, care having been taken to preserve the datum.

I can personally vouch for the correctness of the observations, having had on frequent occasions, as Harbour Engineer, to refer to them during the past 25 years.

The observations are only taken in the forenoon of each day, and as the gauge is not self-registering the daily fluctuations are not determined, which would be very desirable if made for comparison with the meteorological records at the observatory.

Statements of the depth of water on the mitre-sills of the locks at Port Dalhousie and Port Colborne have also been compiled, showing the annual fluctuations of Lakes Ontario and Erie.

The omissions in the Public Works Reports from 1870 to 1875 have been supplied by the courtesy of the Superintendent of the Welland Canal.

The water in Lake Ontario has fallen 12 inches since the 14th of December last, and the level is now the same as last year, viz.: 13 inches above zero.

I am indebted to Professor Kingston, of the Meteorological Observatory, for a perusal of General Comstock's Reports on the United States' Survey of the Lakes, from 1872 to 1876. For the greater convenience of comparing the water level curves of all the lakes a tracing has been made which is submitted for inspection, and the following extracts from the Report of 1876 may be considered as a summary of the observations: "An inspection of the curves will show that: 1. Lakes Huron and Michigan run together so closely that they may be regarded as one lake. 2. On Lake Ontario high water is most likely to occur in May or June, on Lake Erie in June or May, on Lake Huron July and August, and on Lake Superior in August or September. 3. On Lakes Erie and Ontario low water occurs generally in February, on Lake Huron in February, and on Lake Superior in March. 4. Lakes Huron and Erie correspond much more nearly than Lakes Erie and Ontario. 5. Lake Superior fluctuates less than any of the others. 6. The extreme fluctuations between high and low waters in different years are greater on Lake Ontario than on Lakes Erie and Huron. On Lake Ontario high waters in different years may differ in round numbers by three feet; on Lakes Erie and Huron by two feet. 7. Lakes Huron, Erie and Ontario are so connected that high or low water in one in any year indicates high or low water in all. Lake Superior stands alone. 8. The extreme range in monthly means from the lowest water to the highest for a period of 17 years is approximately for Lake Ontario 4½ feet; for Lakes Erie, Huron and Michigan 3½ feet."

The records of extraordinary fluctuations are limited to three instances—though several have been noticed—two of which were observed in Oswego in 1872 and 1873 by officers in charge of the United States survey of the lakes, and one at the Queen's Wharf,

Toronto, on the 24th of April last. The records are as follows: "On the 13th of June, 1872, at Oswego, between 2 and 3 p.m., the water suddenly rose one foot in ten minutes, and afterwards continued to rise and fall until 7 o'clock, the barometer falling nearly all the time. At ten minutes past three a white squall and water spout passed about one and a half mile to the north-west, moving west." At Alcott, 112 miles west of Oswego, the people reported having seen an "immense sea serpent" lashing the waves, which was presumed to be the waterspout before noted. Again at Oswego on the 19th July, 1873, it was observed: "At 3 o'clock the barometer had fallen .05—the water to $2\frac{4}{10}$ths, and the thermometer was 76°; at 5 p.m. the water suddenly rose to $3\frac{4}{10}$th, it was found that the barometer had fallen .07, the wind had shifted to the south-west and the thermometer had risen to 80°. At 5 minutes past 5 the water had fallen again to $2\frac{4}{10}$ths, the wind shifted to the north, blowing fresh, and a waterspout appeared about 4 miles north-north-west moving south-south-west. General Comstock remarks in reference to these reports: "It would seem then, from the consideration of the irregular fluctuations at Milwaukee, Marquette, and Oswego, that a probable cause is to be found in oscillations of the barometer either local or general, and in the accompanying winds periodically arising in some cases by reflection from an opposite shore."

The unusual fluctuation at the Queen's Wharf, Toronto, was observed by Captain Paul, in charge of the Dominion Government dredging. The records as noted were as follows: Queen's Wharf, Wednesday, April 24th, 1878—a.m, cloudy, threatening, wind fresh, east; p.m., heavy squall from south-east, with rain. Extra rise and fall of water $3\frac{1}{2}$ feet above average. Normal state of water, 20 inches above zero. On the 23rd the level was 19 inches, and 25th, 20 inches above zero. The time was not stated, but I was informed shortly after the occurrence that it was in the afternoon. Mr. Carpmael, Deputy Superintendent of the Meteorological Observatory, kindly furnished me with the barometric readings for that day, and between 1.58 p.m. and 2.02 p.m. there was a sudden rise of more than a tenth of an inch, viz., from 29.122 to 29.226, in less than four minutes. Mr. Carpmael mentions, in his notes on the above: "At about 2h. 2min. the wind suddenly increased in force, and veered from east to south, afterwards returning to south-east and east, the force at the same time diminishing." There were no reports of water spouts or sea serpents.

With reference to the tidal theory, General Comstock remarks: "The known existence of a lake breeze at Milwaukee during the summer months at once suggested itself as a cause for this inequality, and on comparing the solar diurnal curve for April and November, when the lake breeze should be weak, and that for July and August, when the lake breeze should be the strongest, with that of the whole season, it was found that for the former months the inequality nearly disappears, while for the latter it is considerably increased, thus justifying the supposition that the lake breeze is the cause of the inequality." On such evidence the so called tidal theory may be dismissed so far as regards the apparent effects on the fluctuations of the lakes.

	1854	1855	1856	1857	1858	1859	1860	1861	1862	1863	1864	1865	1866	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876	1877	1878
Rain fall	27.705	31.650	21.505	33.205	25.051	33.274	23.434	26.925	25.529	20.483	21.430	26.599	34.209	19.041	26.408	31.182	33.893	22.771	16.585	20.232	17.574	19.980	21.063	21.685	43.390
Snow reduced	4.95	2.90	1.50	7.38	4.51	6.44	4.56	7.45	4.74	6.27	7.46	6.33	5.21	11.05	7.87	8.90	12.27	2.96	0.75	11.38	0.77	10.75	11.34	3.73	5.10
	32.655	34.550	23.005	40.585	29.561	39.714	28.994	34.375	29.269	26.753	28.890	32.929	29.419	30.091	34.278	32.042	46.168	25.731	25.336	31.612	24.344	29.730	32.403	25.415	48.490

Average rain fall 25 years 26.527
Do snow do reduced 7.645
Total 34.172
Highest Lowest
Extremes 48.490 1878 24.344 1874

47 above datum Highest level

1879	1880	1881

Rain and Snow fall Average 34.172

Lake Ontario

Average 18.20 above zero

Average 18.20 above zero

Datum line 9 ft at Queen's Wharf

Inches

Chart,
Shewing Rise and Fall of Water
in Toronto Bay, (Lake Ontario) from 1854 to 1878

Compiled and copied from records in Harbour Office.
1878.

Scale 3 ins. to 1 foot

Horizontal Scale 12 months to 1 in.

Vertical Scale 4 inches to 1 in.

N B The datum is taken at 9 feet Queen's Wharf
Heavy black lines show rise & fall each year
Black line indicates average in each year
Difference, highest and lowest level 6.325 in
Average height of water for 25 years 18.28 in above

GEO E DESBARATS LITH MONTREAL

STATEMENT of the Highest and Lowest Water in the Harbour of Toronto, from the year 1854 to 1880, inclusive, also the Rise and Fall.

YEAR.	HIGHEST WATER.		LOWEST WATER.		RISE.		FALL.		REMARKS.
		inches.		inches.		inches.		inches.	
1854	June 21	36½	Dec. 29	6	From Jan. 6	18½	To Dec. 29	30½	Great fall.
1855	Aug. 7	29½	April 2	1	" April 2	28½	" " 28	9½	
1856	June 11	32½	Dec. 15	4½	" Feb. 20	17½	" " 15	28	
1857	July 27	43½	Jan. 30	1½	" Jan. 30	42	" Nov. 3	12½	Great rise, 3 ft. 6 in.
1858	July 13	44	Nov. 30	17½	" Mar. 30	22½	" " 30	26½	
1859	May 31	43	" 14	12½	" Feb. 20	25	" " 14	30½	Great fall.
1860	July 8	24½	" 24	11	" Feb. 20	10½	" " 24	13½	Rise and fall nearly equal.
1861	June 5	39	Jan. 30	9	" Jan. 30	30	" Dec. 27	18	Great rise.
1862	May 21	43½	Dec. 19	8	" Feb. 1	28½	" " 19	35½	Great fall.
1863	May 16	34½	" 15	8	" Jan. 7	25½	" " 15	26½	Rise and fall about equal.
1864	June 5	35½	Feb. 16	4	" Feb. 16	31½	" " 11	24½	Great rise.
1865	May 19	30	Dec. 27	† zero.	" " 4	24	" " 27	30	Great fall.
1866	June 18	20	Feb. 15	* 7	" " 15	27	" No fall.		Water kept up to close of year.
1867	June 17	38	Dec. 26	* 5	" Jan. 17	27	" Dec. 26	43	Great fall, 3 ft. 7 in.
1868	July 1	17	Feb. 6	* 12	" Feb. 6	29	" " 29	19	Lowest water on record.
1869	July 28	27½	Feb. 5	* 2	" " 5	29½	" Nov. 8	13½	
1870	May 6	47	Dec. 29	12	" Jan. 5	26½	" Dec. 26	35	Highest water on record.
1871	May 4	26	Dec. 29	* 6½	" Mar. 1	21	" " 29	32½	
1872	June 22	3½	Mar. 19	* 16½	" No rise.		" " 29	20	Lowest water on record.
1873	May 26	23	Jan. 9	* 15	" Jan. 9	38½	" Nov. 29	19	Great rise.
1874	June 11	29	Dec. 30	* 5	" " 1	20	" Dec. 30	34	Great fall at close of year.
1875	June 24	12	Feb. 17	* 15	" Feb. 17	27	" " 29	16	Very steady all year.
1876	July 5	41	Jan. 10	* 2	" Jan. 10	43	" " 30	31	Great rise.
1877	April 28	18½	Nov. 18	* 1½	" Feb. 28	13½	" Nov. 18	20	Water low all year.
1878	Dec. 14	25	Jan. 5	* 1	" Jan. 5	25	" Oct. 18	14	Water high all year.
1879	Jan. 1	22	Oct. 30	* 6½	" No rise.		" " 30	28½	Gradual fall all year.
1880	June 4	19	Dec. 30	* 7	" Jan. 2	25	" Dec. 27	27	Rise and fall about equal.

* The inches below zero are indicated by asterisks, the rest are above zero.

† Zero point 9 feet at the Queen's Wharf.

HARBOUR MASTER'S OFFICE,
TORONTO, January 28, 1881.

DATES of the Closing of the Harbour of Toronto from 1861 to 1880.

YEAR.	DATE OF CLOSING.	YEAR.	DATE OF CLOSING.
1861	December 7th.	1871	December 21st.
1862	" 12th.	1872	" 12th.
1863	" 16th.	1873	" 10th.
1864	" 16th.	1874	" 12th.
1865	" 31st.	1875	" 23rd.
1866	" 21st.	1876	" 21st.
1867	" 31st.	1877	" 19th.
1868	" 24th.	1878	" 25th.
1869	" 7th.	1879	" 17th.
1870	" 24th.	1880	" 8th.

This is as near as the matter can be ascertained.

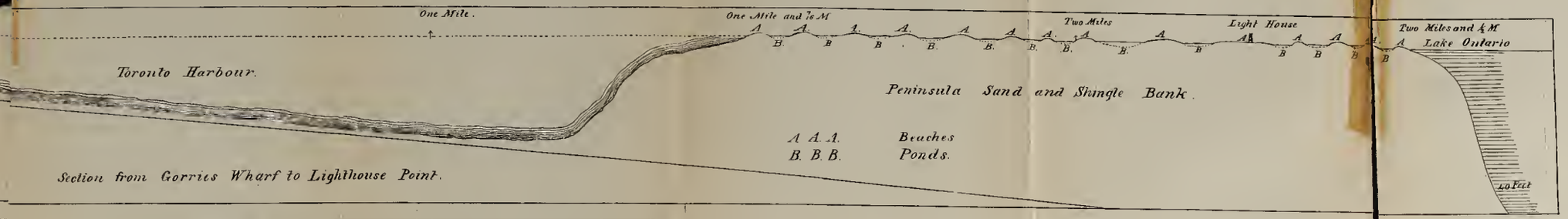
RECORD of the dates upon which the Ice left Toronto Bay, from 1823 to 1880.

YEAR.	DATE OF LEAVING.	YEAR.	DATE OF LEAVING.
1823	April 17th.	1852	April 18th.
1824	" 15th.	1853	March 31st.
1825	March 9th.	1854	April 8th
1826	April 5th.	1855	" 16th.
1827	" 6th.	1856	" 22nd.
1828	February 24th.	1857	" 14th.
1829	April 9th.	1858	March 27th.
1830	" 2nd.	1859	Wanting.
1831	" 1st.	1860	March 15th.
1832	" 15th,	1861	" 5th.
1833	" 4th.	1862	" 3rd.
1834	March 14th.	1863	January 24th.
1835	" 29th.	1864	March 2nd.
1836	April 25th.	1865	" 22nd.
1837	" 21st.	1866	" 18th.
1838	" 1st	1867	April 6th.
1839	" 6th.	1868	" 8th.
1840	March 28th.	1869	" 1st.
1841	April 14th.	1870	" 3rd.
1842	March 18th.	1871	March 11th.
1843	April 20th.	1872	April 12th.
1844	" 4th.	1873	" 14th.
1845	March 20th.	1874	March 16th.
1846	April 8th.	1875	April 16th.
1847	" 11th.	1876	" 11th.
1848	March 30th.	1877	March 25th.
1849	April 1st.	1878	" 9th.
1850	" 4th.	1879	" 25th.
1851	March 28th.	1880	February 19th.

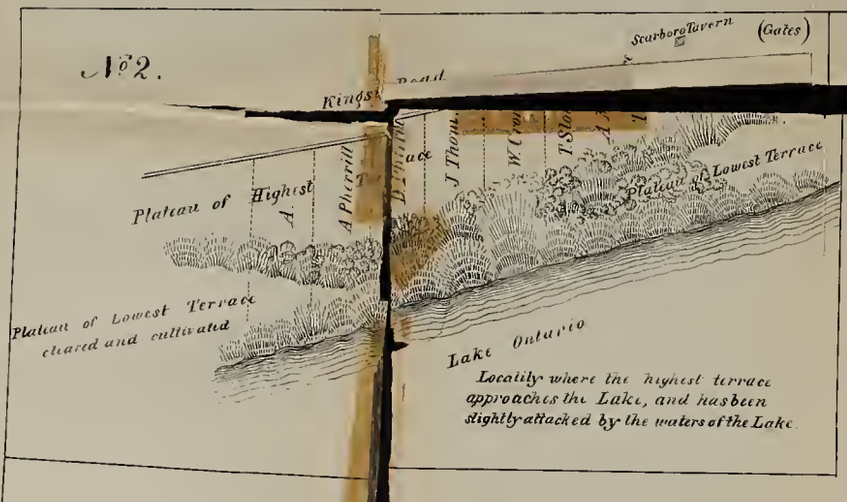
Diagrams to illustrate the First Premium Report

No 1.

Section from Gorries Wharf to Lighthouse Point.



No 2.

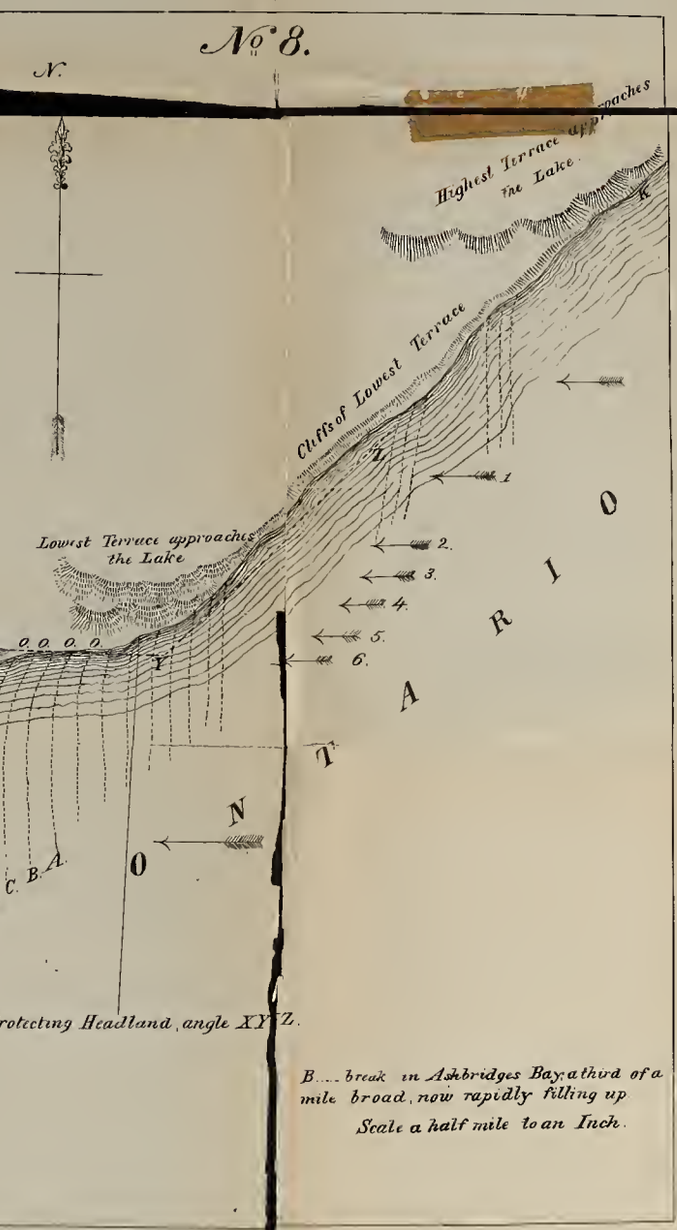


No 3.

Locality where the highest terrace approaches the Lake, and has been slightly attacked by the waters of the Lake.

No 8.

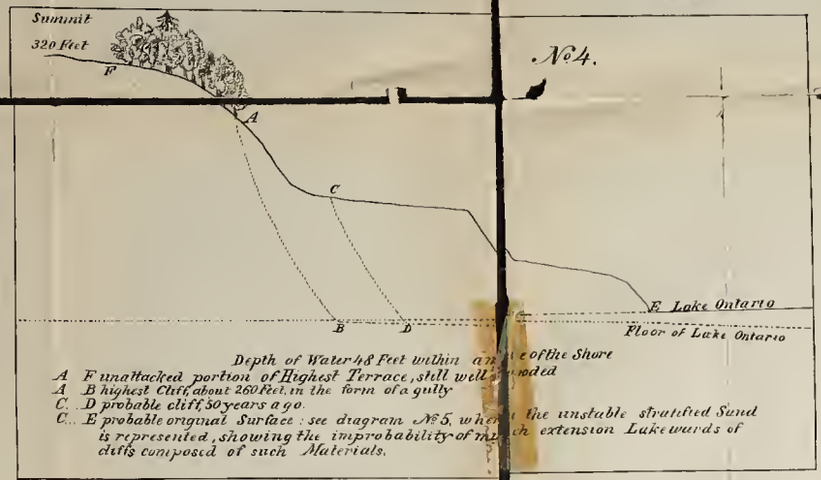
N.



B.... break in Ashbridges Bay; a third of a mile broad, now rapidly filling up

Scale a half mile to an Inch.

No 4.



Depth of Water 48 Feet within an [illegible] of the Shore

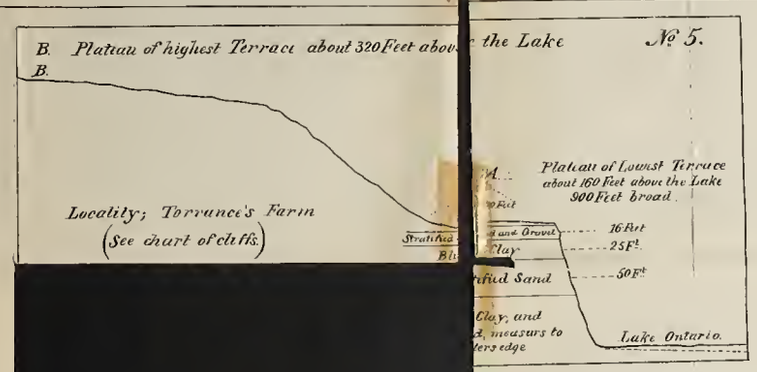
A F unattacked portion of Highest Terrace, still well wooded

A B highest Cliff, about 260 feet, in the form of a gully

C D probable cliff 50 years ago.

C E probable original Surface: see diagram No 5, where the unstable stratified Sand is represented, showing the improbability of much extension Lakewards of cliffs composed of such Materials.

No 5.


B. Plateau of highest Terrace about 320 Feet above the Lake
B.
Locality; Torrance's Farm
(See chart of cliffs.)
Plateau of Lowest Terrace about 160 Feet above the Lake 300 Feet broad.
16 Ft
25 Ft
50 Ft
Lake Ontario.

GEO. E. DESBARATS PHOTO-LITH. MONTREAL

CITY OF TORONTO

THE FORT

NORTHERN RAILWAY GROUNDS

QUEENS WHARF

BATHURST PORTLAND BROCK PETER JOHN SIMCOE YORK BAY YONGE SCOTT CHURCH WEST JARVIS GEORGE FREDERICK SHERBOURNE PRINCESS BERKELEY PARLIAMENT TRINITY CHERRY

WELLINGTON ST FRONT STREET THE ESPLANADE MILL ST

G.T.R. G.W.R. N.R. T.G.R.

STATION FREIGHT SHED ROUNDHOUSE

Hanlans Point

Gibraltar Point

Shore line 1879

Shore line 1876

Shore line 1875

Shore line 1874

26ft 1875

25ft 1875

20ft 1875

15ft 1875

10ft 1875

5ft 1875

REFERENCE

Shore line in 1874
1875
1879

Line of 5ft depth 1874
10
15
20
1875
5
10
15
20
1879
5
10
15

PLAN
OF
TORONTO HARBOR
SHEWING
THE CHANGES OBSERVED
IN
THE EASTERN AND WESTERN ENTRANCES
IN THE YEARS 1874 1875 & 1879

SCALE $\frac{1}{7200}$

Note. The Soundings on the Island represents soil as shewn on map of 1879

GEO E DESBARATS PHOTO-LITH MONTREAL

MAP
OF
TORONTO HARBOR
IN 1841.

GEO E. DESBARATS PHOTO-LITH MONTREAL

Plan of TORONTO HARBOUR, Lake Ontario

Surveyed under the Direction of
Capt.n W.F.W. OWEN R.N.
By Lieut.nt now Commander H.W. Bayfield R.N.
Drawn by Geo. D. Chatfield Lieut.t 90th L.t Inf.t
The Town is copied from a Plan in the Surveyor Generals Office

Latitude of Block House of Assembly 43° 39′ 0 N
Longitude 79° 28′ 0 W

Scale of 4000 Feet

The Soundings are in Feet

1818

TOWN OF TORONTO

Public Square
Russell Square
Government House
House of Assembly
Simcoe Place
Church
Gaol
Civil Government Houses
Mouths of the River Don
Var.n 0° 40′ E.
Government Wharf
Front Road from Fort George to Burlington
Fort
Block House
HARBOUR
Portage
Gibraltar Point
Block House
Lighthouse

Published 28th April 1818

Engraved by [illegible] Photolith Mo[illegible]

BINDING LIST MAY 1 1942

3 plans in pocket.

144232
Gov.Doc. Canada. Public Works, Dept.of
Can Memorandum, with accompanying plans and
Pu documents relative to the past and present
state of the Harbour of Toronto.

NAME OF BORROWER.

DATE.

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Library

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